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Regulatory oversight of nuclear safety in Finland

Annual report 2015

Erja Kainulainen (ed.)

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Radiation and Nuclear Safety Authority

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Management review

In 2015, all Finnish nuclear power plants operated safely and caused no danger to their surrounding environment or employees. The collective radiation doses of employees were yet again historically low and the radioactive releases into the environment very small. The low employee radiation doses were the result of short annual outages and improvements implemented at the nuclear power plants.

Over the course of 2015, Fortum Power and Heat Oy (Fortum) submitted to STUK a total of 13 operational event reports. The operational events did not compromise nuclear or radiation safety. STUK performed an annual outage inspection in compliance with the inspection programme. In this inspection, STUK oversaw the repairs of the primary circuit reactor coolant pumps, in particular. The pumps and the wearing of their spare parts will be reviewed as part of the ageing management inspection in 2016. In 2015, STUK focused its regulatory oversight on inspecting Fortum's management, competence, resource and procurement processes. The Fortum management system renewal project has proceeded as planned.

In 2015, Teollisuuden Voima Oyj (TVO) submitted to STUK 18 operational event reports. The operational events did not compromise nuclear or radiation safety. STUK performed an annual outage inspection in compliance with the inspection programme. A special topic studied during the oversight of annual outages was the replacement of feedwater line mixing points. The mixing points were replaced due to cracks observed during the 2014 annual outage. TVO implemented a new organisation and operations model in 2015. STUK reviewed document updates and safety assessments made based on the change. More work is needed to establish the new operating model, and STUK will continue to monitor the change as part of its regulatory oversight.

At both Olkiluoto and Loviisa NPPs, modifications required for improving safety continued. As a result of the Fukushima accident, four air-cooled heat exchangers were installed at the Loviisa nuclear power plant in 2014 and 2015. They ensure cooling of the fuel in the reactor and the fuel pools in case heat transfer to the sea is lost. Furthermore, separate flood protection improvements have been implemented in some systems important to safety. This work was continued in 2015. STUK continued its review of the Loviisa I&C renewal documents and supervised pre-installation work during the 2015 annual outage. The plan is to complete the first installation stage during the 2016 annual outage, and the I&C renewal should be complete by 2018.

As a result of the Fukushima accident, Olkiluoto will improve, for example, systems used to cool the reactor and add whole new systems for pumping water into the reactor in case of a complete loss of AC power. STUK approved related plans in 2015. Another ongoing project at Olkiluoto is an upgrade of the reactor coolant pumps and the emergency diesel generators. In 2015, STUK continued its review of documents pertaining to the reactor coolant pumps and the supervision of manufacture. TVO plans to commission the new reactor coolant pumps between 2016 and 2018.

In 2015, STUK evaluated how well the operating plant units at Loviisa and Olkiluoto comply with the requirements of the new nuclear safety guides (YVL Guides), decided which requirements will be applied and how safety must be further improved. No major technical modification needs arose in connection with these implementation decisions, as the most important of the new required issues were already implemented or are being implemented after the Fukushima accident. According to STUK's decisions, however, both Fortum and TVO must, in the next few years, expand the coverage of accident analyses, improve ageing management procedures of the plants and further develop plant documentation to promote better traceability of design modifications.

Design, installation and construction work of the Olkiluoto 3 project are almost complete and the commissioning phase will start soon. In 2015, STUK's oversight focused on the finalisation of design and analyses, restarting of activities at the construction site, effects of the TVO's organisational change, commissioning tests and preparation for operation. STUK approved the plant's I&C design and conducted site visits to the I&C testing field in Germany in 2015. The installation work at the plant site, which had been discontinued, was restarted in the summer. STUK paid special attention to good construction site practices after the break. Due to the TVO's organisational change, STUK's inspections focused on the clarity of roles and responsibilities and adequacy of resources for the Olkiluoto 3 project. No major non-conformances in these issues were detected. In 2015, STUK reviewed system commissioning plans. The plan is to start the commissioning tests of the nuclear island systems during the spring of 2016.

On 30 June 2015, Fennovoima submitted a construction licence application for a new nuclear power plant to the Ministry of Employment and the Economy. At the same time, Fennovoima submitted to STUK for review documents regarding the plant site and separate reports required by the Nuclear Energy Decree. Fennovoima will supplement the construction licence application in stages in compliance with its licensing plan between 2015 and 2017. STUK oversaw the development of Fennovoima's management system and quality management, and assessed the company's organisational resources to begin construction of a nuclear power plant. In addition to reviewing the management systems of these actors, STUK conducts inspections to verify that the operations of the organisations comply with the requirements in practice. In September 2015, STUK launched the inspections included in the regulatory inspection programme, and a total of six inspections were carried out in 2015. Furthermore, STUK's experts participated as observers in audits of the plant supplier and its subcontractors, arranged by Fennovoima.

The handling and storage of spent nuclear fuel and operational nuclear waste and disposal of operational nuclear waste were implemented safely, and no events compromising safety were detected at the Loviisa or Olkiluoto nuclear power plants. Due to the successful planning of operations, the plants accumulated clearly less operational waste than nuclear power plants on average. Fortum was able to determine the cause of the cracks observed in the concrete packages at the Loviisa solidification facility for low- and intermediate-level liquid radioactive waste and commissioning of the facility proceeded as planned in 2015. The concrete packages will be placed in the waste disposal facility in the power plant area. In late 2014, Fortum studied the cause and repair methods of cracks observed in the outer surface of a concrete tray in the disposal facility for solidified radioactive waste. The concrete trough must be repaired and the repairs must be approved before the disposal of solidified waste can begin.

The enlargement of the spent fuel storage facility at Olkiluoto, which started in 2009, was completed in 2015 when STUK finalised the safety assessment on commissioning of the extension and approved TVO's application to increase the capacity of the spent fuel storage facility. In connection with the enlargement, the storage structures were modified to correspond to the new safety requirements in terms of an airplane crash, for example.

The operating licence for the research reactor FiR 1 is valid until the end of 2023. However, VTT Technical Research Centre of Finland decided to shut down and decommission the reactor earlier due to financial reasons. VTT stopped using the research reactor in June 2015 and completed the measures needed to keep the reactor in permanent shutdown state by the end of the year. In 2015, STUK continued the oversight of the reactor's operational safety as before. Furthermore, STUK reviewed the requirements on decommissioning and regulatory oversight together with VTT. Since this is the first nuclear facility decommissioning project in Finland, adressing of the requirements and safety issues already before the submission of the licence application is important to ensure effective regulatory oversight.

STUK made implementation decision for the FiR research reactor on 14 YVL Guides. VTT will apply the other requirements from of the old YVL Guides as long as the FiR reactor is in permanent shutdown and during decommissioning. The most important requirements and effects of the implementation decisions on the FiR 1 reactor involved the development of the management system and the development of employee radiation protection for the decommissioning.

STUK finalised and submitted to the Ministry of Employment and the Economy a statement and safety assessment on the construction licence application for the Posiva encapsulation plant and disposal facility in early 2015. STUK's conclusion was that the encapsulation plant and disposal facility can be constructed in such a manner that it will be safe. After the review, STUK also prepared decisions on the documents laid down in section 35 of the Nuclear Energy Decree. In these decisions, STUK posed several requirements on Posiva regarding the construction phase and the preparation of the operating licence application. After the statement, STUK focused on planning the regulatory oversight of the encapsulation plant and disposal facility construction and assessing the requirements with Posiva to ensure that the work done by Posiva based on the plans is sufficient to meet the requirements.

After Posiva received the construction licence from the Government on 12 November 2015, STUK's oversight has focused on the construction phase of the encapsulation plant and disposal facility. The regulatory oversight during the construction phase covers design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components. This stage also includes the nuclear waste facility's commissioning phase, at which time STUK will oversee Posiva's operations, review test run plans and test run results, and perform commissioning inspections. In practice, construction in 2015 focused on the expansion of facilities implemented as part of the underground research facility (Onkalo). STUK oversaw the construction activities and the research in Onkalo to the required extent.

Posiva aims at harmonising its management system and operations with those of TVO and promote the use of shared resources and competences. STUK focused its oversight on ensuring that resources and functions needed to verify the safety of Posiva's nuclear facilities will be taken into account when integrating and reconciling the functions. Oversight takes place as part of the construction inspection programme, for example. STUK launched the construction inspection programme when Posiva received the construction licence. Inspections included in the programme assess the performance of Posiva's management system, the sufficiency of procedures and their ability to guide design, manufacture, construction and installation operations, as well as the taking into account of safety requirements at different stages of the project.

Nuclear safeguards in Finland were implemented in compliance with the international treaties. Nuclear safeguards ensure that nuclear materials and other nuclear items remain in peaceful use in compliance with the relevant licences and declarations, and that nuclear facilities and the related technologies are only utilised for peaceful purposes. STUK maintains a national control system which handles the nuclear safeguards that are necessary for the non-proliferation of nuclear weapons. STUK processed reports and declarations on nuclear materials and performed safeguard inspections together with the International Atomic Energy Agency (IAEA) and the European Commission. Based on these inspections, it was concluded that nuclear energy was used in compliance with the declarations and no undeclared activities were detected.

Based on the amendment of the Nuclear Energy Act that entered into force on 1 January 2016, which changed STUK's mandate on providing regulations, STUK prepared five regulations in 2015. Four of them replaced the Government Degree on the Safety of Nuclear Power Plants, the Government Decree on Emergency Response Arrangements at Nuclear Power Plants, the Government Decree on the Security in the Use of Nuclear Energy and the Government Decree on the Safety of Disposal of Nuclear Waste.
A regulation on the Safety of Mining and Milling Activities to Produce Uranium or Thorium is completely new. Specific requirements that could not be issued in STUK's regulations were transferred to the Nuclear Energy Decree.

Contents

1 Development and implementation of legislation and regulations

Amendments of the Nuclear Energy Act

The Nuclear Energy Act was amended on 1 July 2015. The amendments emphasise the independence of STUK and its regulatory oversight. STUK's mandate in radiation monitoring in the immediate vicinity of nuclear power plants was expanded and STUK received the mandate to give orders regarding nuclear safety issues. Furthermore, regulations on the Government's obligation to take into account STUK's proposals given in the preliminary safety assessment when making a decision-in-principle and the licensing authority's obligation to take into account in the licence conditions the safety proposals given by STUK in the licence application statement were added to the legislation. In addition, charges of the licensee of the nuclear facility and licensee under a waste management obligation were increased for a fixed period of time to allow development of the nuclear safety and nuclear waste management research infrastructure.

Preparation of regulations

The Nuclear Energy Act includes a list of 27 issues in which STUK may impose regulations. The list is based on previous decrees and an amendment of the Nuclear Energy Act in 2011 when the Government was given a mandate to issue safety rules regarding mining and milling activities to produce uranium or thorium.

In 2015, STUK prepared five regulations in project established for this purpose. The regulations were implemented by replacing the Nuclear Energy Act decrees, i.e. the Government Degree on the Safety of Nuclear Power Plants, the Government Decree on Emergency Response Arrangements at Nuclear Power Plants, the Government Decreeon the Security in the Use of Nuclear Energy and the Government Decree on the Safety of Disposal of Nuclear Waste with STUK's regulations. The Regulation on the Safety of Mining and Milling Activities to Produce Uranium or Thorium is completely new.

The revoked Government Decrees included regulations on issues that cannot be governed with STUK's regulations. In these cases, the Government still has the power to decree. Such issues include the limitation of radiation exposure and radioactive releases as well as duties falling under the jurisdiction of other authorities. For these issues, an amendment of the Nuclear Energy Decree entered into force at the beginning of the year. STUK was closely involved in the preparation of the amended decree.

The plan was to retain the contents of the corresponding Government Decrees, except for the above-mentioned issues transferred to the Nuclear Energy Decree. The Regulation on the Disposal of Nuclear Waste was updated based on experience gained from the processing of Posiva's construction licence application and regulatory activities of other nuclear power plants. The regulation was also standardised in terms of structure and content to correspond to the Regulation on the Safety of Nuclear Power Plants. The most important change is the fact that the design extension condition included in the nuclear facility regulations is also taken into account in the case of nuclear facilities that process spent nuclear fuel. These changes clarify the design of nuclear waste facilities and specify the regulations on long-term safety of nuclear waste.

Official hearing of the draft regulations was arranged in the summer. The consultation period and the parties to be heard are specified in the legislative amendment: licensees, Advisory Committees on Nuclear Safety and Security Arrangements, the Ministry of Employment and the Economy, the Ministry of Social Affairs and Health, the Ministry of the Interior, the Ministry of the Environment, the rescue authorities and other authorities, if necessary. An event for stakeholders was arranged during the consultation period, on 12 August 2015, to present the legislative amendment and the individual draft regulations. A total of almost 450 proposed corrections or comments were issued during the hearing and in the comments of the revised draft regulations thereafter. STUK has recorded how these comments were taken into account in the regulations and the justification for the decisions made.

The draft regulations were presented to the Advisory Committee on Nuclear Safety in its meeting in August, at which time the committee issued a statement regarding the current draft regulations. The regulations, finalised based on the hearing comments, were presented to the new advisory committee in its kickoff meeting in December.

The STUK regulations prepared based on the amendment of the Nuclear Energy Act and their justifications were published on 31 December 2015 on Finlex in Finnish and Swedish.

Implementation of YVL Guides

The nuclear safety guidelines (YVL Guides) cover all issues influencing the safety of a nuclear power plant, such as design, operation, safety of the plant and its environment, nuclear materials, nuclear waste, structures and equipment. The renewed guides were competed in late 2013 and have been applied as such to new nuclear facility projects, such as the Fennovoima nuclear power plant project, ever since. The YVL Guides entered into force for the currently operating plant units at Loviisa and Olkiluoto and the FiR 1 research reactor of VTT Technical Research Centre of Finland with separate STUK's implementation decisions in 2015. The YVL Guide implementation decisions for the Olkiluoto 3 plant unit, which is currently under construction, will be made when processing the OL3 operating licence application.

In an YVL Guide implementation project, STUK assessed guide-specific reports by the licensees, focusing on the processing of non-conformances and measures proposed by the licensees. An assessment of compliance with requirements was completed as spot tests, but the assessment will be continued in connection with the continuous oversight (such as in inspections of the periodic inspection programme). The project covered 42 YVL Guides and around 8,000 requirements included in them.

In 2015, STUK processed a total of 98 implementation decisions for TVO, Fortum and VTT. All of the YVL Guides (except for YVL A.11) entered into force for the operating plant units of TVO and Fortum during the autumn of 2015 or at the latest as of 1 January 2016. Implementation decisions on 14 YVL Guides for the FiR research reactor of VTT were made. They entered into force as of 1 January 2016. VTT will apply the other regulations of the old YVL Guides, where applicable, as long as the FiR reactor is in permanent shutdown and during decommissioning. More than 60 people participated in the STUK implementation project, using 4–5 man-years.

The YVL Guide requirements and the power companies' responses (compliance, references to verifying plant documentation, proposals on justified improvement measures, etc.) were entered into STUK's Polarion database. STUK's comments on compliance with the requirements, STUK's decisions on whether the licensees' proposals on exemptions from a requirement are approved, STUK's additional requirements, justification, STUK's policies and revision needs of the YVL Guides were also entered into the database. In the future, the database will be used as a tool in continuous oversight.

No major technical modification needs arose for the operating plant units at Loviisa and Olkiluoto in connection with the implementation project, as almost all of the new required issues were already implemented after the Fukushima accident (2011). According to STUK's decision the operating units must, in the next few years, expand the coverage of accident analyses, improve ageing management procedures of the plants and further develop plant documentation to promote better traceability of change design.

2 Results of regulatory oversight of nuclear power plants in 2015

2.1 Loviisa 1 and 2

STUK oversaw the safety of the Loviisa power plant and assessed its organisation in different areas by means of reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and the YVL Guides, and by overseeing operations at the plant. Inspection of the periodic safety review that started in 2014 was also continued. Summaries of inspections included in the periodic inspection programme for 2015 are included in Appendix 4. On the basis of this regulatory oversight, STUK can state that plant operations did not cause a radiation hazard to the employees, population or the environment.

Radiation safety of the plant, personnel and the environment

The limit value for the collective dose of a nuclear power plant's employees averaged over two successive years is 2.5 manSv per one gigawatt of net electrical power. This means an average value of 1.24 manSv for the Loviisa plant units. This threshold was not exceeded at either of the units. The collective occupational dose at Loviisa 1 was 0.28 manSv and the collective occupational dose at Loviisa 2 was 0.24 manSv. The combined radiation dose of both units, 0.52 manSv, is the lowest ever recorded. The improvement was due mostly to the improved radiation safety working methods and the replacement of reactor coolant pump seals with seals that do not contain any antimony in 2014. Activated antimony from the primary circuit piping has been a major source of radiation in the steam generator room.

The effective dose for a single worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any single year. The actual radiation doses remained clearly below these limits.

Radioactive emissions into the air and sea remained clearly below the set plant site specific emission limits. The calculated radiation dose of the most exposed individual in the vicinity of the plant was around 0.07 µSv per year, i.e. less than 0.1% of the set limit (Appendix 2, indicator A.I.5c).

A total of approximately 300 samples were collected and analysed from the land and marine environment surrounding the Loviisa power plant in 2015. External background radiation and the exposure to radioactivity of people in the vicinity of the NPP were also regularly measured. Minute amounts of radioactive substances originating from the plant were observed in some of the ana-

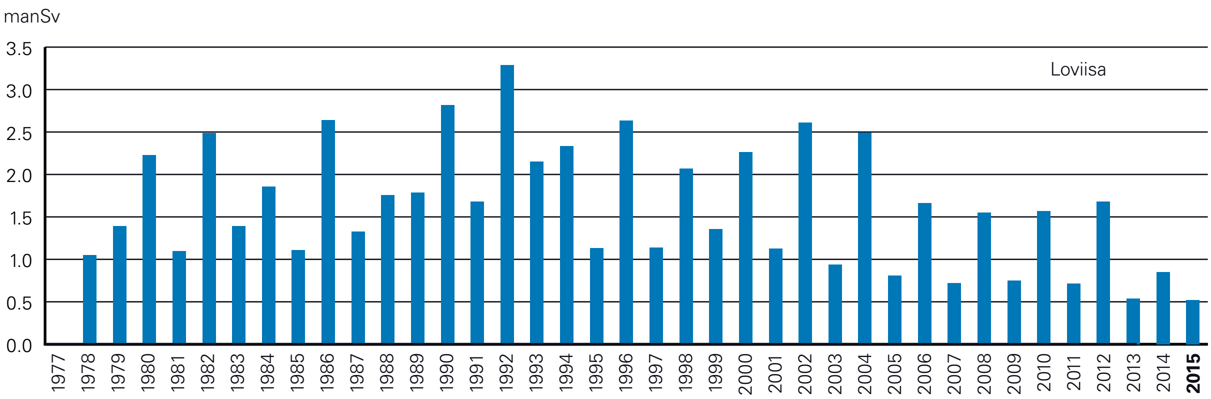


Figure 1. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

lysed environmental samples. The amounts were so small that they are insignificant in terms of the radiation exposure of the environment or people.

Operation and operational events

In 2015, the Loviisa nuclear power plant submitted to STUK for information or approval a total of 13 operational event reports. These reports comply with the new Guide YVL A.10, meaning that they include the former special reports, major operational transients and other plant events submitted to STUK for information. Detecting and investigating non-conformances is important in terms of operating experience feedback. Based on STUK's oversight and the submitted operational event reports, one can state that Fortum has established and functional procedures to identify, investigate and report events. The only development areas are investigation of more minor events, streamlining of the reporting process and assessment of the impact of corrective measures. The operational events in 2015 did not compromise nuclear or radiation safety. The most important operational events are described in Appendix 3.

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. In addition to refuelling and modifications, a large number of maintenance measures and inspections are carried out during each annual outage to ensure the safe and reliable operation of the NPP. The annual outage inspections were carried out on schedule and in the planned scope. As part of the oversight, STUK performed an annual outage inspection in compliance with the periodic inspection programme. In this inspection, STUK oversaw the repairs of the primary circuit reactor coolant pumps, in particular. Damage that was more extensive than normal was observed in the parts subject to wear of the reactor coolant pumps. STUK requested separate reports on this damage before startup of the unit. The pumps and the wearing of their spare parts will be reviewed as part of the ageing management inspection in 2016. More information about annual outages of the plant units is available in Appendix 3.

Development of the plant and its safety

Several modification projects that will improve plant safety that were designed based on assessments of the Fukushima accident are currently ongoing at the nuclear power plant. These modifications will improve the provisions for extreme external threats.

A heat sink independent of sea water was installed in 2014–2015 and tested during the 2015 annual outage at the Loviisa nuclear power plant as part of the safety improvements included in the Loviisa renovation programme. The heat sink is backed up by air-cooled cooling units. Two cooling units have been installed in both plant units. They can be used to cool the fuel pools via an intermediate circuit and transfer the reactor's residual heat from the emergency cooling system to the atmosphere. The towers are designed for a long-term loss of heat sink (more than 72 hours).

As part of the preparations for high seawater level, Fortum added in 2015 flooding protection in compliance with its own assessment in emergency systems where they might be necessary under extreme conditions. The modifications included, for example, raising the temporary dams and protecting the reserve emergency feedwater pumping plant by adding waterproofing to the walls and doors, and adding flooding protection in drains to be used if necessary.

During the 2014 annual outage, new main steam line (RA) safety valves were added in Loviisa 2. It was observed during commissioning tests after installation that the safety valves' forced opening function is not able to open the valves at the designed low pressure. STUK required that Fortum submit, before starting Loviisa 2 after the 2014 annual outage, to STUK for approval a preliminary report on how the opening of the safety valves at a higher pressure would influence transfer of the plant into a safe state after an accident. The issue was discussed further in 2015 and based on analyses and reports by Fortum, using the valves' forced opening function to reach a safe state after a rare design extension condition is possible. Operating manual modifications are still needed, however. The plan is to install similar valves in Loviisa 1 during the 2016 annual outage.

New main steam line (RA) radiation measuring instruments were installed and commissioned at Loviisa 2. Fortum decided to postpone the commissioning of the new RA radiation measuring instruments for Loviisa 1 to the 2016 annual outage to ensure the adequacy of spare parts, for example. Furthermore, operating experience from the radiation monitors at Loviisa 2 can be utilised at Loviisa 1.

STUK continued the review of the documents of the Loviisa I&C renewal (the ELSA project; formerly the LARA project) and supervised pre-installation work during the 2015 annual outage. The work was completed as planned. Document review of the Loviisa I&C renewal has proceeded on schedule, and top level documents for the first implementation phase (2A) have been approved. The plan is to perform the stage 2A installation during the 2016 annual outage. The I&C renewal should be complete by 2018. Planned renewal of the refuelling machine and reactor building crane at the Loviisa NPP did not proceed much in 2015. STUK approved an updated conceptual design plan of the reactor hall crane.

Periodic safety review

STUK continued the inspection of the Loviisa periodic safety review. According to the terms of the operating licence that was granted to Fortum in 2007, the licensee must prepare comprehensive safety assessments for the Radiation and Nuclear Safety Authority by the end of the years 2015 and 2023. The licensee submitted the required documents in several batches in 2014–2015. A request for information regarding the document batch submitted by the licensee in late 2014 was made, and the necessary answers were received in late 2015. At the end of the year, STUK started the drafting of its own safety assessment based on the licensee's reports. Key issues in this periodic safety review include ageing management, implementation of the new YVL Guides (a separate project, but an important interface), as well as the licensee's safety culture and safety management. STUK will finalise the safety assessment and make a decision regarding it in 2016 based on STUK's new regulations and the YVL Guides.

Emergency preparedness

STUK oversaw the ability of the power plant's emergency preparedness organisation to operate under exceptional conditions and performed an emergency preparedness inspection included in STUK's operation monitoring programme. The inspection is described in Appendix 4. Emergency preparedness at Loviisa nuclear power plant complies with the key requirements. No events requiring emergency response actions took place at Loviisa NPP in 2015.

An unannounced emergency preparedness drill, LOVIISA-15, was arranged at Loviisa NPP in November. In addition to the plant itself, participants in the drill included STUK, Eastern Uusimaa Fire and Rescue Services, Eastern Uusimaa Police Department and Kerava Emergency Response Centre. The drill tested the response time in forming of the emergency preparedness organisation and how operations can be started outside regular working hours, as well as offered training to new employees. A similar drill was arranged last in 2010.

Nuclear security

STUK assessed the security arrangements of the nuclear power plant by performing two inspections of the periodic inspection programme (Appendix 4) and other inspections. No significant deviations were detected in the inspections. The measures resulting from remarks made in the course of earlier inspections were also considered to be appropriately implemented. The inspections covered renewal of the surveillance system in 2014, personnel training and preparation of the implementation of the new YVL Guides (A.11 and A.12). Furthermore, a separate safety arrangement readiness drill was arranged in October. STUK also participated in the drill. The drill tested and trained the employees of the alarm centre and the security personnel in a situation where outsiders attempt to enter the plant with the help of an employee. The drill was successful: the attempted infiltration was detected and properly handled. The security organisation identified, alone and in cooperation with STUK, development areas that will be improved in the security organisation's future drills and training events.

Fire safety

Fire safety at the Loviisa nuclear power plant is at an acceptable level. In 2015, STUK oversaw the plant's fire safety with an inspection included in the periodic inspection programme (Appendix 4), with site visits and by reviewing reports submitted by Fortum.

In its inspection, STUK paid attention to minor leaks and leakage marks in the fire water piping that were observed in a condition survey and fire compartmentalisation of the plant's new fibreglass seawater piping that is used to remove residual heat and that was in use during the 2015 annual outages. Reports about these issues were requested for information. Modifications that improve fire safety implemented in 2015 include new fire water piping and triggering centre for a transformer substation (10AT01), automatic fire extinguishing systems for the operational waste facilities and a manually operated water extinguishing system in the motor room of the reactor coolant pumps.

Organisational operations and quality management

Based on STUK's oversight, one can state that, with a view to ensuring safety, the Loviisa nuclear power plant organisation has operated in a systematic and development-oriented way. STUK oversaw the operations of the Loviisa nuclear power plant organisation and competence management by, for example, performing three inspections included in the periodic inspection programme (Appendix 4). STUK focused its regulatory oversight particularly on Fortum's management, competence management, resource management and procurement processes. Fortum's nuclear operations management system renewal project has proceeded according to plan: the top level process map, key processes and supporting processes have been identified. Furthermore, STUK monitored the development of quality management in the development of Fortum's procurement operations and Fortum's extensive training project on good practices that was carried out in 2015.

Operational waste management

The processing, storage and disposal of low and intermediate level waste (NPP operational waste) at the Loviisa nuclear power plant were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. The NPP pays attention to keeping the amount of waste generated as low as possible by very efficiently reducing the volume of waste and releasing from control waste that contains very little radioactive substances. Fortum updated its procedures on the release of operational waste and hazardous waste from control in 2015. STUK has approved the licensee's procedures and will follow the amount of waste released from control and its activity concentrations.

New nuclear safety guidelines

In 2015, STUK will evaluate how well the plant units Loviisa 1 and Loviisa 2 as well as Olkiluoto 1 and Olkiluoto 2 meet the requirements of the new nuclear safety guidelines and decisions on how safety must be further improved. No major technical modification needs arose in connection with the implementation decisions, as the most important of the new required issues were already implemented after the Fukushima accident. According to STUK's decisions, however, both Fortum and TVO must, in the next few years, expand the coverage of accident analyses, improve ageing management procedures of the plants and further develop plant documentation to promote better traceability of design modifications.

In terms of the solidification facility for liquid radioactive waste, STUK oversaw commissioning tests of concrete containers, which were completed and approved. Fortum submitted to STUK for approval an operating licence application for starting production operation of the solidification facility. STUK processed the application and prepared its safety assessment in late 2015. The safety assessment was completed in 2016 and STUK approved the starting of production operation.

Fortum first detected corrosion damage on the outer surface of a concrete vault in the hall for the solidified waste in the disposal facility for low- and intermediate-level waste in August 2014. According to Fortum's report, the vault can be repaired. Weeping drains in the underground hall around the vault must be improved to manage the environmental stress to which the vault is subjected. The intermediate-level waste facility is not in use yet and no nuclear waste has been placed there. STUK will approve the commissioning of the disposal facility when method has been solved and the vault has been repaired.

Nuclear safeguards

In 2015, a total of twelve nuclear safeguards inspections were carried out at the Loviisa nuclear power plant. STUK performed an inspection pertaining to the verification of the physical inventory of nuclear materials together with the IAEA and the European Commission both before and after the annual out-

Forgeries of small valve material certificates

Valves where the material certificates for the materials of some components were forgeries have been delivered to the Loviisa and Olkiluoto nuclear power plants. In July, a company that sells valves to the nuclear power plants notified Fortum and TVO that a wholesale metal dealer that sold raw materials to the valve manufacturer had forged additional test certificates. Such valves were also delivered to nuclear power plants in other countries. Studies revealed that the valves installed in the Finnish nuclear power plants did not compromise the safety of the plants.

A total of 209 valves with unclear material certificates due to the above-mentioned forgeries were delivered to the Loviisa nuclear power plant. According to a preliminary report submitted by Fortum and additional surveys done in connection with the annual outage, most of the valves were installed in measuring piping. The suspected materials proved compliant with the requirements in inspections, except for a batch of four valves, two of which had already been installed at the plant. These valves were replaced in connection with the annual outage. STUK has processed Fortum's reports and non-conformance reports regarding the material certificate forgery and noted that the rest of the suspected valves can be approved for use.

A total of 107 valves whose material properties had to be studied were delivered to the Olkiluoto nuclear power plant. According to a report by TVO, such valves were installed in Olkiluoto 1, Olkiluoto 2 and the interim storage facility for spent nuclear fuel, but the forgeries did not affect Olkiluoto 3. A ban on the use of the valves in storage was imposed. Based on the report, the document forgeries have not influenced the valves' operability. Furthermore, proper certificates obtained directly from the material manufacturer were available for the valve components, and determining that the components meet the requirements was possible based on these certificates. However, as an additional confirmation TVO plans to review some of the material analyses. Processing of this case will be continued, because TVO has submitted an updated report of the incident. Furthermore, the installed valves and the valves in storage that are currently under the ban will be approved by means of non-conformity processing as fit for use.

ages. Furthermore, STUK inspected the locations of the reactor core fuel assemblies prior to closing of the reactor cover in Loviisa 1 and Loviisa 2. STUK performed two interim safeguards inspections. One of the inspections focused on the nuclear use items at the plant, such as the control rod drive mechanism, the fuel transport baskets, the instrument for measuring fuel assembly geometry and the spare devices in the outer warehouse. Furthermore, the Commission and the IAEA performed an extra inspection and IAEA completed one visit on maintenance of the surveillance cameras. No remarks were made in the inspections. The remote data transmission system installed in 2014 was operational in 2015.

2.2 Olkiluoto 1 and 2

STUK oversaw the safety of Olkiluoto nuclear power plant and assessed its organisation in different areas by means of reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and overseeing operations at the plant. Summaries of inspections included in the periodic inspection programme for 2015 are included in Appendix 4. On the basis of this regulatory oversight, STUK can state that plant operations did not cause a radiation hazard to the employees, population or the environment.

Radiation safety of the plant, personnel and the environment

The limit value for the collective dose of a nuclear power plant's employees averaged over two successive years is 2.5 manSv per one gigawatt of net electrical power. This means an average annual dose value of 2.20 manSv per Olkiluoto plant unit. This threshold was not exceeded at either of the units. The collective occupational dose at Olkiluoto 1 was 0.24 manSv and the collective occupational dose at Olkiluoto 2 was 0.51 manSv.

Radioactive emissions into the air and sea remained clearly below the set plant site specific emission limits. A total of approximately 300 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto nuclear power plant in 2015. Minute amounts of radioactive substances originating from the plant were observed in some of the analysed environmental samples. The amounts were so small that they are insignificant in terms of the radiation exposure of the environment or people.

Operation and operational events

In 2015, TVO submitted to STUK for information or approval a total of 18 operational event reports. These reports comply with the new YVL Guide A.10, meaning that they include the former special reports, major operational transients and other INES-classified events submitted to STUK for information. Detecting and investigating non-conformances is important in terms of operating experience feedback. Based on STUK's oversight and the submitted operational event reports, one can state that TVO has established and functional procedures to identify, investigate and report events. The operational events in 2015 did not compromise nuclear or radiation safety. The most important operational events are described in Appendix 3.

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. A large number of maintenance measures and inspections are also carried out during each annual outage to ensure the safe and reliable operation of the NPP. Non-destructive inservice inspections of pressure equipment were implemented in compliance with an inservice inspection programme approved by STUK. STUK performed an annual outage inspection in compliance with the periodic inspection programme during the annual outage. Special attention was paid to the replacement of the mixing point of the feedwater system piping and piping from the reactor coolant system of the shut down reactor. The mixing points were replaced due to cracks observed during the 2014 annual outages. More information about the annual outages of the plant units and the cracks at the piping mixing points is available in Appendix 3.

Development of the plant and its safety

Several modification projects that will improve plant safety that were designed based on assessments of the Fukushima accident are currently ongoing at the nuclear power plant. These modifications will improve the provisions for extreme external threats. STUK approved the system-level pre-inspection documents of the high pressure core cooling system. TVO will install a steam turbine-driven core cooling system to manage a situation where a total loss of AC power has occurred. The plan is to commission the system in 2017 and 2018. STUK also approved a conceptual design plan submitted by TVO on ensuring residual heat removal in a case where the primary heat removal route is unavailable. This plan is connected to the development of the diversity principle, which was a requirement of the previous periodic safety review of 2009.

Dependence of the auxiliary feed water system on seawater was eliminated at Olkiluoto 1 in 2014. The dependence was eliminated by implementing a modification where the recirculation lines are connected to the demineralised water storage pools that are also the water source of the auxiliary feedwater system, and cooling of recirculated water with seawater is no longer necessary. The modification will not influence the operation of the system in any other operating mode apart from the recirculation mode. Abnormal vibration and sounds were observed in the new recirculation line during commissioning, however. Furthermore, springs on the pressure side of the auxiliary feedwater system pump broke off during commissioning. This did not influence operation of the pumps, however, and

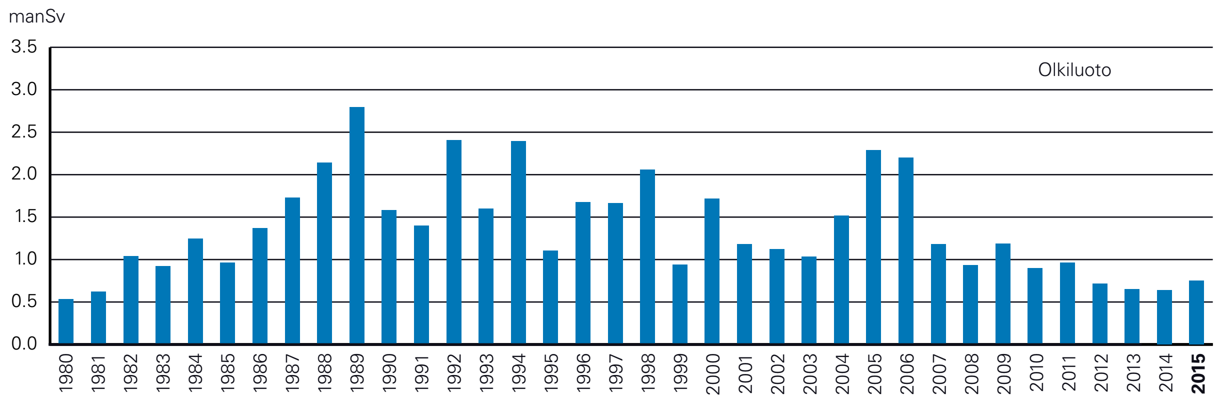


Figure 2. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

the fault would not have prevented the supply of water to the reactor in case of need. Studying of the problems, most of which occurred in train D, was continued in 2015. A new observed phenomenon is instantaneous exceeding of the recirculation line design pressure when switching from recirculation mode to pumping to the reactor. STUK approved a strength analysis submitted by TVO, which is connected to this issue. The studies aiming at eliminating the problems continue and TVO has proposed several alternative further measures. A similar modification of the recirculation line will not be implemented at Olkiluoto 2 until the studies are completed.

A project on replacing the reactor coolant pumps and the frequency converters needed to control and supply power to the pumps, as well as a project on replacing the NPP's emergency diesel generators are also ongoing at the Olkiluoto NPP. STUK continued its review of documents pertaining to replacement of the reactor coolant pumps and the supervision of manufacture. TVO plans to commission the new reactor coolant pumps between 2016 and 2018. In the emergency diesel generator project, eight of the power plant's emergency diesel generators will be replaced and a ninth generator will be built. The diesel generator project has been delayed and TVO estimates that all of the new diesel generators will be installed and commissioned by the spring of 2022. The new diesel generators can be cooled with seawater and air. The current ones can be cooled only with seawater.

Emergency preparedness

STUK oversaw the capability of the emergency preparedness organisations of the nuclear power plant to act under abnormal conditions. Emergency preparedness at Olkiluoto nuclear power plant complies with the key requirements. No events requiring emergency response actions occurred at Olkiluoto NPP in 2015. An unannounced emergency preparedness drill was arranged in the autumn. For more information on the drill, please see the next chapter.

Nuclear security

In 2015, two emergency drills on threatening situations were arranged at Olkiluoto. STUK also participated in the drills. A drill on cooperation between the nuclear power plant and the authorities involved a scenario complying with the design basis threat. The security organisation eliminated the threat in accordance with the protection goal. The unannounced drill assessed fluency of communications between different organisations, among other issues. Over the course of the year, STUK monitored the security organisation's refresher training on the use of force. TVO has developed the drill reporting procedures and the monitoring of measures as part of the assessment of the performance of its security arrangements. In addition, STUK assessed the NPP's security arrangements by performing three inspections of the periodic inspection programme (Appendix 4). STUK approved the Olkiluoto security policy. It covers the TVO and Posiva nuclear facilities in the same area.

Fire safety

Fire safety at the Olkiluoto nuclear power plant is at an acceptable level. In 2015, STUK oversaw fire safety of the NPP by means of regulatory inspections and site visits, and by reviewing reports submitted by TVO.

Organisational operations and quality management

Based on STUK's oversight and the results of operating activities, it can be stated that with a view to ensuring safety TVO's organisation has operated in a systematic and development-oriented way. TVO implemented a new organisation and operations model in 2015. STUK has reviewed document updates and safety assessments made based on the change. Based on STUK's oversight, one can state that the new operating model has been introduced but some work to establish the practices is still needed. STUK will actively monitor the effect of the change on TVO's operations.

Operational waste management

The processing, storage and disposal of low- and intermediate-level waste (NPP operational waste) at Olkiluoto NPP were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. The NPP pays attention to keeping the amount of waste generated as low as possible by very efficiently reducing the volume of waste and releasing from control waste that contains very little radioactive substances. TVO updated its procedures on the release of metal waste from control in 2015. STUK has approved the licensee's procedures and will follow the amount of waste released from control and its activity concentrations.

Enlargement of spent fuel storage facility

TVO enlarged the interim storage facility for spent nuclear fuel (KPA storage) at Olkiluoto with three new pools and modified the storage structures to comply with the new safety requirements against airplane crash, for example. STUK approved TVO's application on increasing the storage capacity of the spent fuel storage facility Based on STUK's safety assessment, one can state that the KPA storage enlargement presented in TVO's application meets the requirements laid down in sections 5–7 of the Nuclear Energy Act.

Nuclear safeguards

A total of eighteen nuclear safeguards inspections were performed in 2015. STUK performed, together with the IAEA and the European Commission, inspections on the physical inventory of nuclear materials at both plant units and the spent nuclear fuel storage facility both before and after the annual outages. Furthermore, STUK inspected the locations of the reactor core fuel assemblies prior to the closing of the reactor cover in Olkiluoto 1 and Olkiluoto 2. STUK reviewed and approved an updated nuclear safeguards manual submitted by TVO. Nuclear safeguards equipment and methods of the European Commission were renewed in the reactor buildings of both plant units and in the spent fuel storage facility.

The International Atomic Energy Agency (IAEA) and the European Commission launched remote data transmission in nuclear safeguards at the Olkiluoto units in November 2015. Remote data transmission reduces the number of onsite inspections by the international organisations at the Finnish nuclear power plants. Enabling the electronic transfer of monitoring data is an obligation laid down in the additional protocol of the Safeguards Agreement between Finland and the IAEA.

2.3 Olkiluoto 3

STUK continued its assessment of Olkiluoto 3. Design, installation and construction work of the project are almost complete and the commissioning phase will start soon. In 2015, STUK's oversight focused on the finalisation of design and analyses, restarting of activities at the construction site, resource issues, effects of the TVO organisational change, commissioning tests and preparation for operation.

STUK's oversight of system design focused mainly on assessment of the I&C. The I&C design was completed slower than the other design areas. Another design focus area has been verifying the compliance of design with the requirements by means of analyses and tests, for example. Issues pertaining to commissioning and future operation of the plant unit were discussed in several inspections and meetings both from the technical viewpoint and from the viewpoint of the organisation.

Based on the construction inspection programme and other oversight activities by STUK, the methods, operations and adequacy of TVO's organisation have mainly been found to be at a good level, for example as far as the commissioning of the plant is concerned. During construction, TVO and the plant supplier have taken into account modification needs that have emerged as design of the various engineering disciplines have matured. Deficiencies detected in manufacturing and installation have either been corrected so that the original quality requirements are met, or it has been demonstrated by means of additional inspections or analyses that the requirements are met. In summary, based on the results of regulatory oversight, STUK is able to state that the original safety targets of the plant can be achieved.

Design

Over the course of the year, STUK approved the plant's I&C system design and other systems whose design was completed later than that of other systems, such as the radiation measuring system and the diesel building ventilation system. The conceptual plant design and system design have now been approved. STUK also reviewed and approved modifications of system design. Modifications have been necessary when, for example, systems designed at different times have been reconciled to each other.

The most important component that is still being processed is the pressurizer safety valve station, which will protect the plant's primary circuit from overpressure. Some parts of the valve represent new design, and modifications have been made because of problems observed during testing. Performance of the modifications and the whole were tested in France. STUK monitored some of the tests onsite. At the end of the year, STUK received valve design documents where the modifications have been taken into account. STUK approved the design documents but requested some supplements. Testing of the valve station continues and STUK has required that the test results be submitted to STUK and STUK be given the opportunity to monitor the testing.

STUK inspected several updated design documents of steel platforms. Unlike in the original plans, the safety significance of the steel platforms has increased because process piping and safety critical equipment will be supported on them. The design documents were approved without remarks.

Analyses and testing

As part of the system design assessment, STUK has inspected analyses that verify compliance of design, such as system failure mode and effects analyses, strength analyses of mechanical components and their initial data, such as load specifications and load descriptions. Most of the system failure mode and effects analyses were approved but STUK required several supplements and clarifications to the main I&C system failure mode and effects analyses. The load specifications and load descriptions were of good quality and STUK did not have any remarks regarding them.

The transient and accident analyses included in the final safety analysis report of Olkiluoto 3 were submitted to STUK for a pre-review in late 2014. Their review continued in 2015. STUK did not observe any major deficiencies in the analyses. STUK ordered independent comparison analyses of the overpressure analyses, severe accident analyses and a variety of pipe breaks. The procedures and calculation software used when creating the comparison analyses are not the same as the procedures and tools used by the plant supplier. Results of the comparison analyses corresponded to the results of the plant supplier's analyses, i.e. the comparison analyses verified the correctness of the plant supplier's analyses. Some comparison analyses are still unfinished.

I&C testing in the test bay in Germany continued. STUK performed some site visits to the test bay and monitored selected tests. The tests were completed by the end of the year and no major deficiencies or problems in design were observed. STUK reviewed applications on transferring the systems from the test bay to the plant site after testing, and most of the main I&C systems were transferred to Olkiluoto by the end of the year.

Qualification of I&C components, which had proceeded slowly so far, started to proceed more quickly. Qualification ensures that the components will operate as planned under all the conditions determined for them, including potential accidents. STUK observed some deficiencies in the delivered documents, such as out of date or missing information, and required that the deficiencies be corrected.

An updated probabilistic risk assessment (PRA) for Olkiluoto 3 was not submitted to STUK in 2015. STUK aimed at ensuring with its regulatory oversight that content and up-to-dateness of the materials regarding the PRA and its applications that are to be submitted as appendices to the operating licence application, as well as their compliance with the requirement level laid down in the YVL Guides, were ensured.

Manufacture, installation and construction

The installation work at the plant site, which had been discontinued, was restarted in the summer. STUK paid special attention to good construction site practices after the break. TVO's actions to ensure fluency of work and orientation of new employees and organisations were discussed in several meetings. TVO's procedures on supervising the construction site and control the restarting of work were also covered by two inspections included in the construction inspection programme. One of the inspections took place before the start of installation work and the other after the work had started. It was noted in the first inspection that TVO has established installation supervision practices and practices for the orientation of new contractors. When the installation work had started, STUK performed an unannounced inspection covering the adequacy of installation supervision resources. Based on the inspections, TVO's resources were deemed sufficient.

Modifications of nuclear island cabling, which started in the autumn of 2014, continued throughout the year. The modification project will update the plant's cabling to comply with the current system design. STUK oversaw the work on the cabling onsite in connection with its site visits. Furthermore, STUK monitored the testing of electricity systems onsite. STUK performed a construction inspection programme inspection electrical engineering. It covered management of electrical engineering modifications and TVO's installation inspection resources. One requirement was posed in the inspection: it required presentation to STUK of the results of the mapping of software-based components used in the electricity systems.

The I&C inspection also covered installation, testing and change management practices. No requirements were posed based on the inspection. The inspected activities were appropriate, but the commissioning change management procedures were still at such an early stage that they will be revisited in future inspections.

In addition to inspections carried out in accordance with the construction inspection programme, STUK also inspected TVO's installation supervision in connection with regulatory activities onsite to verify the sufficiency of TVO's supervision methods and resources. During daily oversight, compliance with approved procedures was monitored, among other things. Furthermore, STUK verified the practical implementation of security arrangements with site walk-downs in two construction inspection programme inspections on physical security arrangements and information security.

The actual construction work was already completed before 2015. Thus, construction oversight activities were minor and mostly consisted of the installation supervision of the steel platforms.

Commissioning

System commissioning tests in the turbine island have been completed, insofar as testing was possible without the nuclear island. Some electricity system testing has taken place at the nuclear island. Fire prevention systems of the plant have also been tested. Extensive commissioning testing at the nuclear island cannot be started until the process systems have been finalised, the operational I&C has been installed and its tests have been completed. The current plan is to start commissioning tests of the nuclear island systems during the spring of 2016. More and more system commissioning programs have been submitted to STUK. When reviewing these plans, STUK has focused on assessing coverage of the tests and the approval criteria. The plans have been of a good quality and STUK has been able to approve most of them without any remarks. TVO's procedures to ensure coverage of testing were covered in a construction inspection programme inspection in September. STUK deemed TVO's procedures sufficient.

In 2015, STUK performed two inspections included in the construction inspection programme that covered planning of security arrangements for the different commissioning phases. No deficiencies influencing safety were observed in the inspections.

Pressure and leak tightness tests of the Olkiluoto 3 containment were already completed in early 2014, but the final results of the tests were not submitted to STUK for review until in January 2015. The results prove that the containment meets the set leaktightness and strength requirements. STUK approved the result report but noted that according to the testing standards, the leak test must be repeated before commissioning of the reactor if more than 36 months have passed after the first test.

In addition to technical trial runs, commissioning also includes verification of the organisation's capability to operate the plant in a safe manner. The prerequisites of safe operation include an adequate number of licensed operators and the necessary plant documentation, such as procedures and the operational limits and conditions.

The operational limits and conditions (OLC) were submitted to STUK for review in 2014 and their review continued in 2015. STUK submitted its review observations to TVO but did not approve the operational limits and conditions yet. OLC are part of the operating licence application documentation and will be approved in connection with the operating licence application. This review was a pre-review that aims at facilitating the processing of the actual operating licence application.

STUK monitored the progress of operator training, development of the training simulator and preparation of plant guidelines. These issues were discussed with the licensee and plant supplier in several meetings. STUK participated as an observer in an audit by TVO of the plant supplier's training unit. The training simulator has now been updated to comply with the current status of plant design. A number of trial runs must be run on the

Reports on reactor pressure vessel quality at Olkiluoto 3

In April 2015, the French nuclear safety authority ASN announced that non-conformances that affect strength had been detected in the carbon content of the head and bottom of the reactor pressure vessel at the nuclear power plant currently under construction at Flamanville in France. Olkiluoto 3 is of the same type as the Flamanville unit, but the pressure vessel at Olkiluoto has not been manufactured by the same company as the one in Flamanville. However, the manufacturer of the Flamanville pressure vessel has manufactured some of the components in the Olkiluoto 3 reactor coolant system. Uniform quality of the reactor coolant system components at Olkiluoto 3 was monitored during manufacture and no non-conformances were observed. STUK also participated in the monitoring during manufacture. STUK still required TVO to provide a report on material manufacture of the reactor pressure vessel and the other reactor coolant system components in the summer of 2015. In its report submitted in late June, TVO announced that the Olkiluoto reactor pressure vessel has been manufactured using a method other than the method used when manufacturing the Flamanville pressure vessel and the alternative method is superior in terms of quality. TVO also noted that similar problems would have been detected in the inspections performed in connection with manufacture. According to a supplementary report submitted by TVO to STUK in early November, the other reactor coolant system components were properly inspected in connection with manufacture. TVO inspected the carbon content of the steel used in the manufacture of a reactor coolant system pressurizer in October. The measurement results showed that the carbon content complies with the requirements. STUK reviewed the reports submitted by TVO and found that they are sufficient and the conclusions made are well justified.

simulator before operator training can be started. The trial runs will be used to assess whether the simulator describes the actual plant accurately enough for it to be used in training. The plan is to start the trial runs in early 2016 and to complete them by August.

Organisational operations

Focus areas of organisational oversight were effects of TVO's organisational change, restarting the operations at the construction site after the hiatus and preparation of the organisation for the future operation of the plant.

TVO completed a major organisational reform in the spring of 2015. Performance of the organisation was covered in several inspections of the construction inspection programme. The inspections focused particularly on the clarity of roles and responsibilities in the TVO organisation and the adequacy of the resources for the Olkiluoto 3 project. It was observed in the inspections that the new organisation with its new roles and new operating methods were still somewhat unclear to some of the employees. STUK did not observe any deficiencies that could compromise nuclear or radiation safety in the definition of responsibilities or other issues, however.

Over the course of the year, TVO and the plant supplier speeded up the closing of the project's open issues: schedules were prepared, responsible persons were named and progress of work was monitored with more care. The status of open issues was covered in a quality assurance inspection of the construction inspection programme in the autumn. STUK is of the opinion that the situation has improved over the past six months due to the measures taken by TVO and the plant supplier.

Quality management system of the OL3 project will be more closely connected to the TVO management system when the operating licence is applied. At that time, the general part of TVO's management manual, approved by STUK, will be in use. It will be supplemented with a quality plan prepared specifically for OL3. TVO submitted the quality plan to STUK at the end of 2015.

Review of documents related to the operating licence application

STUK has agreed with TVO that STUK may review parts of the operating licence application documents before the delivery of the actual operating licence application. The pre-review will balance the workload of the various parties as completed thematic sections can be reviewed in advance. The documents submitted for pre-review must form a logical entity, and represent the final plant design. As a result of the pre-review, STUK will present a decision including potential observations and requests for further clarifications. The pre-review also functions as practice for the review procedures planned for the operating licence phase. All the documents that are delivered to STUK in connection with the operating licence application will be reviewed by STUK at the operating licence phase as a whole, and STUK will approve their key parts before delivering a safety assessment and a statement on the operating licence application to the Ministry of Employment and the Economy.

STUK continued with the review of the documents submitted for pre-review in 2014 (FSAR Section 15, Accident analyses, and FSAR Section 16, Operational limits and conditions). Several sections of the final safety analysis report were submitted to pre-review in 2015: Section 3 (General design bases), Section 8 (Electric power), Section 10 (Turbine island), Section 12 (Radiation protection) and Section 20 (Decommissioning). Review of Section 3 was still underway at the end of the year, but STUK finished reviewing the other sections and submitted its observations to TVO. No major deficiencies were observed in the review.

Nuclear safeguards

STUK performed a safeguards inspection of the Olkiluoto 3 design information (basic technical characteristics) with the IAEA and the European Commission in November 2015. The inspection focused on verifying the key areas for the safeguards of nuclear materials, such as fuel storage locations and transfer routes. Plans on installation of nuclear safeguards equipment at the plant were also reviewed.

2.4 Hanhikivi 1

Preparation for processing of the construction licence application

In the spring, of 2015 STUK provided, at the licence applicant's request and by virtue of the Nuclear Energy Act, preliminary instructions to Fennovoima as Fennovoima prepared for the construction licence phase. STUK participated in meetings on various themes with Fennovoima and the plant supplier Rosatom Overseas (RAOS), and participated in the assessment of the project's principal suppliers as an observer. STUK provided training for Fennovoima's employees on the YVL Guide requirements, STUK's experience in oversight of plant projects and lessons learned from STUK's inspections of the Olkiluoto 3 project.

STUK organised and launched its own oversight project FIN6 on processing of the construction licence application. STUK will also participate in national and international cooperation between authorities regarding the project. STUK has continued the development of requirement management procedures and tools for the processing of the construction licence application.

Starting the processing of the construction licence application in the autumn of 2015

On 30 June 2015, Fennovoima submitted a construction licence application for a new nuclear power plant to the Ministry of Employment and the Economy. Fennovoima simultaneously submitted licensing documents by virtue of the Nuclear Energy Decree to the Radiation and Nuclear Safety Authority for the launching of a safety assessment. The Ministry of Employment and the Economy studied issues pertaining to the ownership of the project after the application had been filed and submitted a request for a statement to STUK on 8 September 2015. In the request, the Ministry asked STUK to provide a statement and a safety assessment as well as a statement from the Advisory Committee on Nuclear Safety on the project by the end of 2017, if possible.

In connection with the construction licence application, the section of the preliminary safety analysis report on the plant site, the general part of the safety analysis report, part of the sections describing project quality assurance and some separate reports required by section 35 of the Nuclear Energy Decree were submitted to STUK for processing. Fennovoima will supplement the construction licence application in stages in compliance with its licensing plan between 2015 and 2017. STUK started processing of the delivered parts of the construction licence application. A decision to discontinue the processing of the general part of the safety analysis report was made in the autumn of 2015 because the submitted material did not meet the Finnish requirements. In late 2015, Fennovoima updated its licensing plan and some of the licensing document batches that were originally to be submitted in late 2015 were postponed to 2016.

STUK continued the project and subject-specific meetings with Fennovoima and the plant supplier RAOS after the construction licence application had been filed. Finnish licensing and safety requirements as well as available solutions to meet these requirements were discussed in the project meetings and the subject-specific meetings. STUK emphasised the importance of thorough licensing planning in the success of the project's official processing.

STUK monitored the development of Fennovoima's management system and quality assurance, and assessed the company's organisational resources to begin construction of a nuclear power plant. Furthermore, STUK's experts participated as observers in audits of the plant supplier and its subcontractors, arranged by Fennovoima. Fennovoima started audits in late 2014, focusing on assessing the compliance of the project's key design and supply organisations.

During the processing of the application documentation linked to the construction licence application of the Hanhikivi 1 plant project STUK assesses both technical compliance of the plant and ability of the organisations of the licensee, the plant supplier and the main service providers to construct and ultimately operate a nuclear power plant. In addition to reviewing the management systems of these actors, STUK conducts inspections to verify that the operations of the organisations comply with the requirements in practice. STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. Inspections are planned biannually. In 2015, a total of six inspections were performed:

- Management and processing of safety issues
- Management system and key processes
- Fennovoima's safety culture
- Security arrangements
- Resources and competence management
- Principal designer inspection

The inspection results will be used when preparing STUK's safety assessment and statement on the construction licence. A summary of the RKT inspection results is available in Appendix 6.

In order to arrange the operator's own control activities and the safeguards of nuclear material arranged by STUK and international parties, it is important to include the safeguard requirements in the design and construction of new plants as early on as possible. In June, Fennovoima submitted a description on how to arrange the safeguards that are necessary to prevent the proliferation of nuclear weapons. In October 2015, Fennovoima submitted to STUK and the European Commission an update to the preliminary basic technical characteristics (BTC) of Hanhikivi 1. The European Commission assigned Material Balance Area code WFV1 for the plant and submitted the information to the IAEA.

2.5 Research reactor

The operating licence for the research reactor FiR 1 is valid until the end of 2023. VTT Technical Research Centre of Finland has decided to shut down and decommission the reactor earlier due to financial reasons. VTT stopped using the reactor in June 2015 and placed it in permanent shutdown. STUK submitted a statement on this to VTT on 23 April 2015. VTT plans to submit an application on revision of the operating licence to allow for decommissioning in early 2017.

STUK monitored safety of the research reactor by reviewing materials provided by the licensee, as well as by carrying out inspections in line with the periodic inspection programme and the YVL Guides. STUK assessed the updated physical protection procedures of the research reactor, taking into account the decommissioning plans. On the basis of this regulatory oversight, it could be stated that reactor did not pose any radiation hazard to the employees, the population or the environment.

As stated in Chapter 1, implementation decisions for the FiR 1 research reactor were made on 14 YVL Guides which were deemed pertinent at the upcoming decommissioning phase. Based on the decisions, the management system of FiR 1 will be developed in many ways and annual reporting will be somewhat expanded. Radiation protection of the employees and monitoring of radiation exposure will be improved in preparation for the demolition phase. Performance of the emergency preparedness organisation during the permanent shutdown and decommissioning will be taken care of. Attention will be paid to criticality safety, monitoring condition of the nuclear fuel during the permanent shutdown and safety of transfers.

Decommissioning and waste management

VTT submitted an updated nuclear waste management plan for the research reactor to the Ministry of Employment and the Economy in September 2015. It was an update to the 2014 report, and it included all measures and further measures taken after the preparation of the last report. Based on a request by the Ministry of Employment and the Economy, STUK submitted to the Ministry a statement on the VTT nuclear waste management report on 12 November 2015. In the statement, STUK emphasised preparation for risks pertaining to the returning of nuclear fuel and preparation of the six-year plan required by virtue of section 74 of the Nuclear Energy Decree.

Nuclear safeguards

In nuclear safeguards, VTT's material balance area and site cover the nuclear materials in the Otakaari 3 building and related activities. At the end of 2014, VTT submitted to the European Commission the basic technical characteristics (BTC) of the Centre for Nuclear Safety, which is currently under construction. The plan is to move some of the nuclear materials to the Centre for Nuclear Safety. The Commission assigned the Centre for Nuclear Safety a new Material Balance Area code for nuclear material accountancy. In 2015, STUK reviewed VTT's site declaration accordant to the Additional Protocol of the Safeguards Agreement, reviewed together with the Commission the nuclear material accountancy and approved the deputy nominated by VTT for the person responsible for nuclear safeguards.

2.6 Spent nuclear fuel encapsulation plant and disposal facility

In early 2015, STUK completed the processing of the documents submitted in connection with Posiva's construction licence application for the nuclear waste facility. After the review, STUK prepared approving decisions on the documents laid down in section 35 of the Nuclear Energy Decree. Furthermore, STUK prepared comprehensive inspection reports to support decisions on the preliminary safety analysis report and post closure safety case. In addition to the reviewed documents, results and related conclusions of STUK's inspections during the processing of the construction licence application were taken into account.

A statement and a safety assessment on the construction licence application for the Posiva nuclear waste facility were prepared by STUK and a statement on the construction licence application was requested from the Advisory Committee on Nuclear Safety. Feedback given by the advisory committee was taken into account when finalising STUK's statement and the safety assessment. STUK's statement, the safety assessment and the statement of the Advisory Committee on Nuclear Safety were submitted to the Ministry of Employment and the Economy on 12 February 2015.

In decisions related to the documents required in section 35 of the Nuclear Energy Decree, STUK posed several requirements to Posiva. As a result of these requirements, several meetings with Posiva on the disposal facility, development of the long-term safety case and supervision of the manufacture of engineered barriers, for instance, were arranged over the course of the year. Posiva's supplementary plans due to the requirements were discussed in these meetings. Furthermore, follow-up meetings on quality management, construction planning and proving feasibility of the engineered barriers were arranged with Posiva.

In 2015, STUK submitted requests for additional information on system design of the Posiva nuclear waste facility. The requirements included in the decision on the preliminary safety analysis report were further specified in these requests. Issues pertaining to system design, such as system modifications and fault tolerance analyses, have been discussed on regular meetings with Posiva. Planning of the transport of spent nuclear fuel has also been discussed in the meetings with Posiva.

According to section 7 k of the Nuclear Energy Act, naming of the responsible manager of construction and the persons responsible for ensuring of security, emergency preparedness arrangements and nuclear safeguards and their deputies requires that competence of the candidates and their deputies has been assessed and STUK has approved them. In 2015, STUK arranged competence assessment events for the people proposed by Posiva and approved the proposed people.

After submitting the statement and the safety assessment on the construction licence application, focus of STUK's oversight project switched to the planning of oversight for the construction phase of Posiva's nuclear waste facility. Oversight of construction will also take into account the issues for which further information was requested during the construction licence application phase. STUK started oversight of the construction of Posiva's nuclear waste facility when Posiva received a construction licence from the Government on 12 November 2015. Based on experiences obtained during the construction licence application phase, organisation of STUK's oversight activities was changed to better correspond to the construction supervision and inspection needs during construction of the facility.

When the construction licence was granted, STUK launched the construction inspection programme. Inspections included in the programme assess the performance of Posiva's management system, the sufficiency of procedures and their ability to guide design, manufacture, construction and installation operations, as well as the taking into account of safety requirements at different stages of the project. The programme aims at performing around ten onsite inspections per year. The inspection focus areas will be determined every six months. The programme was launched in late 2015 when the construction licence had been granted and two inspections were performed in 2015: an inspection of the monitoring of the disposal facility and a management inspection. One of the goals of these inspections was to assess readiness of the Posiva organisation to carry out the construction project. The inspections and their results, as well as the requirements by STUK, are described in more detail in Appendix 7. STUK also continued oversight and assessment of Posiva's auditing activities by participating in three supplier audits by Posiva in 2015. The regulatory oversight during the construction phase covers design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components. The oversight also includes the nuclear waste facility's commissioning phase, at which time STUK will oversee Posiva's operations during commissioning, review test plans and test results, and perform commissioning inspections of components, structures and systems.

During the construction phase, Posiva will develop its post closure safety case in compliance with STUK's requirements. STUK will oversee and monitor development of the disposal facility and the post closure safety analysis, for example.

The focus of the development of the management system will switch from design to implementation and preparation of commissioning. One of the goals as of 2015 is harmonizing the management system procedures with the procedures of TVO where possible. This also applies to Posiva's safety culture and its assessment and development. Posiva will close its safety culture programme and workgroup, and participate in the future in the Group-level (TVO–TVONS–Posiva) safety culture programme where annual organisation-specific action programmes are developed. STUK has assessed the implemented change and posed requirements about it to Posiva. Observations regarding the safety culture are discussed in more detail in Appendix 7.

In 2015, Posiva implemented two organisational changes. One of them was part of TVO's reorganisation. With the new organisational model, Posiva aims at improving the comprehensive monitoring of the nuclear facility project, particularly its development and links between plant projects. Furthermore, Posiva is planning to adopt a project-centred approach to almost all of its operations. In order to assess Posiva's new organisational structure, operating model and safety culture development methods, STUK has required that Posiva submit to STUK updated personnel resource plans and project plans, the Group-level (TVO, TVONS and Posiva) safety culture assessment and development action plan and Posiva's action plan for 2016. Furthermore, STUK has requested that Posiva systematically update all management system guidelines that are affected by the organisational changes.

In 2015, Posiva has developed the security arrangements in compliance with STUK's requirements, which – in STUK's opinion – has promoted Posiva's security arrangement competence. STUK has assessed the security arrangement competence of the responsible manager for construction and approved the information security manager.

Oversight of the construction of the research facility (Onkalo)

Construction of underground facilities at Onkalo continued in the demonstration rooms and technical rooms. At the construction site above ground level, Posiva prepared construction of the encapsulation plant and disposal facility, and constructed the next part of the hoisting device building. STUK approved rock engineering plans for the expansion of the technical rooms.

Construction of Onkalo was overseen with construction site inspections and construction follow-up meetings. Furthermore, STUK implemented its construction inspection programme for Onkalo until the construction licence was granted. An inspection on disturbances caused by excavation, which was part of the programme, was held in June 2015.

Posiva is engaged in continuous development of the disposal system in the underground facilities. In connection with the design and implementation of the disposal facility, Posiva develops a rock classification system and related detailed modelling at the construction depth of rock structures. Posiva monitors disturbances caused by the excavated underground rooms and assesses how the construction disturbances could influence post closure safety of disposal facility. The development, monitoring and assessment are included in the scope of STUK's oversight activities. In 2015, these issues were monitored in construction follow-up meetings and by reviewing reports submitted by Posiva.

Nuclear safeguards

STUK has implemented nuclear safeguards of disposal in compliance with the national regulatory plan. Finland is the first country in the world to implement safeguards of nuclear materials on a disposal facility, which is why STUK holds a key position in the future development and implementation of international safeguards of nuclear materials regarding geological repositories.

In November 2015, STUK, the Commission and the IAEA inspected the basic technical characteristics of the future disposal facility in the research facility to verify that the facility has been built in compliance with the declaration. The EU Joint Research Centre (JRC/Ispra) assisted the IAEA and Commission by measuring and updating an independent 3D model of the research facility to use as the basis of future inspections by international organisations. Comparisons with previous measurements to detect any changes were also made.

The international safeguard concept for disposal has been developed in cooperation with the IAEA, the Commission and Posiva. In 2015, several meetings on the oversight of the encapsulation plant and disposal facility were arranged between the IAEA, the Commission, STUK, Posiva, TVO and Fortum. Active interaction ensures that the safeguard activities planned by the international organisations can be implemented in practice at the Posiva facilities. The plan will be updated and maintained as plant design proceeds.

3 Regulatory oversight of other forms of nuclear energy use

In addition to nuclear facilities, STUK's oversight covers other uses of nuclear energy, such as the production of uranium, the possession of nuclear materials, as well as R&D activities pertaining to the nuclear fuel cycle.

Mining and mineral processing

In a sulphide mine at Talvivaara in Sotkamo, metals are separated by means of bioheapleaching, where uranium is dissolved from the ore in addition to other metals. Talvivaara Mining Company Plc prepared for the extraction of uranium by building a separate facility, but the commissioning of the facility has been delayed. A Government decision on a licence for the separation of uranium by virtue of the Nuclear Energy Act was appealed and the permit is not legally valid. In 2015, a new company, Terrafame Oy, started operations at Talvivaara. Terrafame has not applied for a new permit, which means that the commissioning of the uranium separation facility did not proceed at all in 2015.

A complaint about STUK's oversight activities at Talvivaara was lodged with the Chancellor of Justice in 2015. STUK submitted a report about the case to the Office of the Chancellor of Justice. In its decision, the Chancellor of Justice stated that based on the submitted documents and taking into account the applied regulations, the Radiation and Nuclear Safety Authority was not guilty of any unlawful or erroneous procedures that would require action by the supreme guardian of law. The complaint did not lead to any action by the Chancellor of Justice.

Small amounts of uranium are being separated in the production processes of Freeport Cobalt Oy in Kokkola and Norilsk Nickel Harjavalta Oy in Harjavalta. STUK has reviewed their inventory reports on the production of uranium.

In 2015, the IAEA requested in its annual oversight meeting additional information about the extraction of uranium at Talvivaara and the processing of ore concentrate that contains uranium, originating in Greenland, in Finland. STUK provided the IAEA with the requested additional information and stated that nothing to declare took place at Talvivaara and the latter case did not involve ore concentrate falling under the oversight scope of safeguards.

Other inspections and approvals

According to the new Guide YVL D.1, all operators must prepare a nuclear material manual that includes instructions on the implementation of nuclear safeguards. In 2015, STUK processed 19 manuals, of which 14 were approved to be taken into use. Some holders of a small amount of nuclear materials abandoned their operations and the manual of one new holder of a small amount of nuclear material was not finished by the end of 2015. A couple of the operators have separate manuals on nuclear safeguards for nuclear materials and R&D activities, because they have separated these functions. The stakeholders have named responsible persons for R&D activities pertaining to the nuclear fuel cycle, but STUK did not approve them because the operations are subject to a notice, i.e. a licence is not required.

Also operators with nuclear material inventories in the Helsinki University Laboratory of Radiochemistry and the Radiation and Nuclear Safety Authority were inspected. No remarks were made in the inspections.

In 2015, STUK granted VTT and Platom Oy licences for the possession and transfer of nuclear information regarding the Fennovoima nuclear power plant. The Geological Survey of Finland was granted a licence for possession, processing, use and storage of nuclear materials.

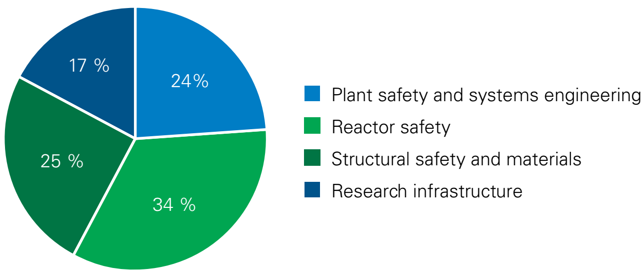
4 Safety research

Publicly funded safety research on the use of nuclear energy has a key role in the development and maintenance of nuclear technology expertise in Finland. The previous publicly funded four-year safety research programmes on the use of nuclear energy, SAFIR2014 and KYT2014, were competed and a new four-year nuclear safety programme, SAFIR2018, and a four-year nuclear waste management programme, KYT2018, were launched in 2015.

Without safety programmes like SAFIR and KYT, developing the expertise needed to support the authorities would not be possible in Finland. According to the Nuclear Energy Act, research funded by the Finnish State Nuclear Waste Management Fund (VYR) aims at ensuring that the authorities have access to comprehensive nuclear expertise. Both STUK and the licensees have hired several people who have obtained their training for expert positions in the field of nuclear energy use and oversight in publicly funded research programmes. The safety research programmes also have an important role in the training of organisations that provide STUK with technical support services, such as the VTT Technical Research Centre of Finland, the University of Helsinki, the Aalto University, the Geological Survey of Finland and Lappeenranta University of Technology.

The total volume of the four-year SAFIR research programme that was concluded in 2014 was EUR 40 million and 279 man-years of research. More than a hundred experts from STUK, the power companies, research facilities and universities participated in the guidance of the programme. The programme created new analysis and measuring methods and 1,244 publications on issues integral to the safety of nuclear energy. These issues are: 1) humans, organisations and society, 2) I&C and control rooms, 3) fuel research and reactor analysis, 4) thermal hydraulics, 5) severe accidents, 6) structural safety of reactor coolant systems, 7) structural engineering safety, 8) probabilistic risk assessment and 9) infrastructure. The programme's concluding seminar was arranged in March 2015. 200 experts from eight countries participated in the seminar.

The new SAFIR2018 safety research programme consists of 33 projects that were selected in the autumn of 2014 based on a competitive bidding. The available VYR funding for the research was around EUR 5 million. The total funding of the research programme was reduced from the previous year for two reasons: firstly, the plant power level in an update of the decision-in-principle for Fennovoima's Hanhikivi 1 nuclear power plant project in December 2014 was lower than in the previous decision, which reduced the licensee's VYR fund contribution by almost EUR 450,000, and secondly, research facilities reduced their share to close to the



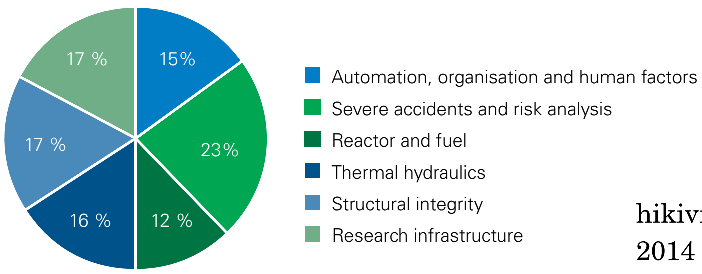


Figure 3. Research areas of SAFIR2018 programme and their shares of the total funding in 2015.

required own contribution. Research projects used to be larger and the goal has been to create multidisciplinary projects to promote multidisciplinary cooperation and achievement of an overall idea of safety. Volume of the SAFIR2018 research programme is EUR 8.2 million, which is divided into three areas as illustrated in the image: 1) overall safety and management of design, 2) reactor safety and 3) structural integrity and materials. VTT Technical Research Centre of Finland and Lappeenranta University of Technology (LUT) will use around 17% of the entire public funding for safety research when reforming the national infrastructure. The research programme covers all issues integral to nuclear safety, and it will create and maintain expertise, analysis methods and experimental readiness to resolve any surprising safety issues.

When the SAFIR2018 research projects had been selected, six steering groups were established in the programme in addition to the three research areas. The steering groups take care of the academic control of research. Members of the supporting groups were named from organisations important to the research of the use of nuclear energy in the summer of 2015. The supporting groups are: 1) I&C, organisation and human factors, 2) severe accidents and research of risks, 3) reactors and fuel, 4) thermal hydraulics, 5) structural integrity and 6) research infrastructure. The supporting groups were named based on the research areas. All of the projects included in one support group are usually part of a single research area. An exception to this is the second support group, which includes both projects pertaining to the determination of plant design bases and projects developing safety analysis methods. The infrastructure support group operates in the SAFIR2018 safety research organisation alongside the research areas (Fig. 4).

The projects included in the SAFIR2018 pro-

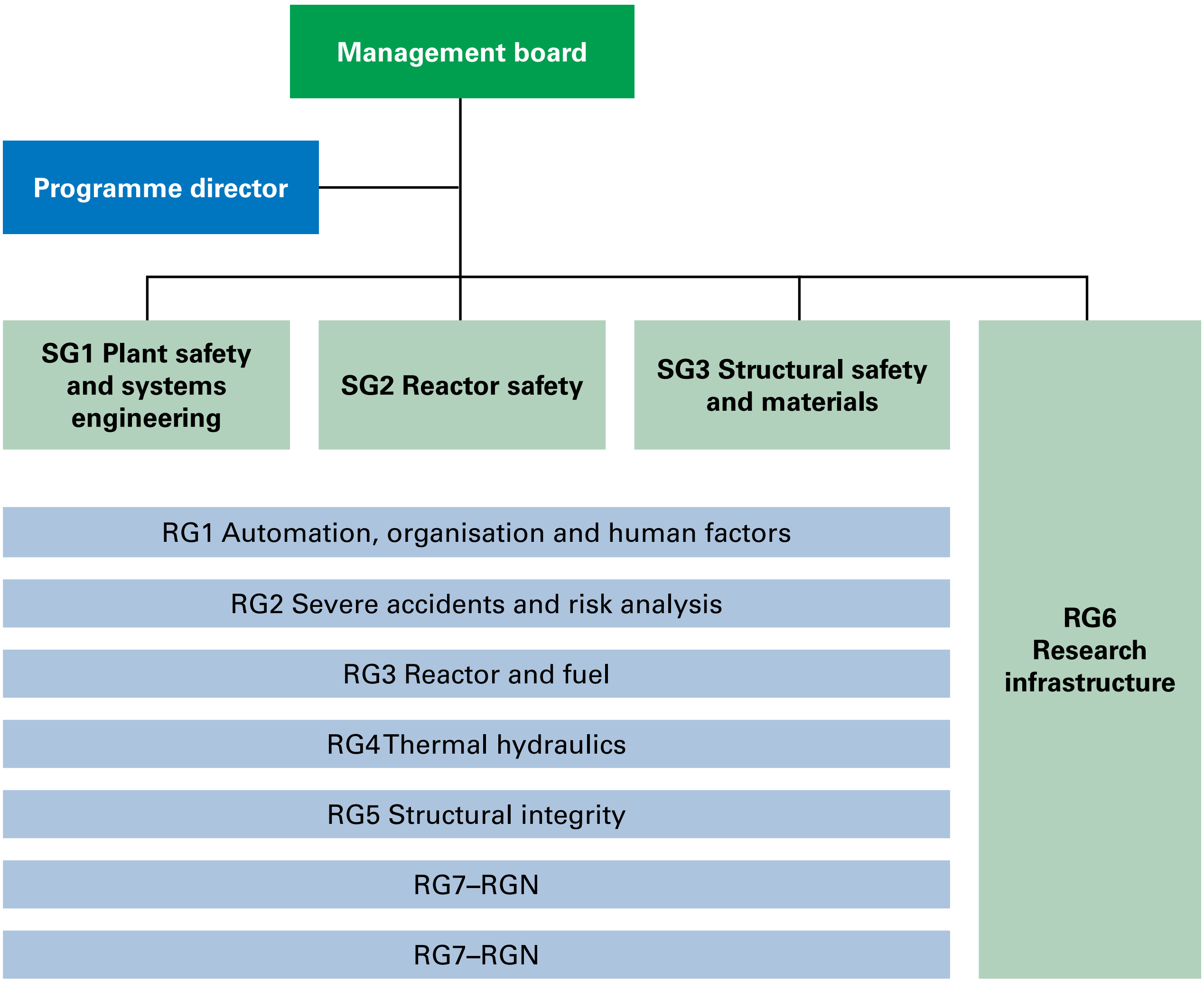


Figure 4. The administrative structure of SAFIR2018 research programme.

Table 1. Distribution of VYR funding of KYT2014 research areas in 2011–2014.

Research area/1000 €	2011	2012	2013	2014
New and alternative technological solutions	120	117	120	123
Safety case	140	155	50	–
Performance of buffer and backfilling materials	350	400	410	410
Long-term durability of the canister	280	300	350	341
Other safety relevant research	725	630	707	783
Social science studies related to nuclear waste management		28	28	45
Total	1615	1630	1665	1702

gramme for 2015 meet the requirements set for VYR-funded research. Special challenges of the research programme include the reduced funding and the large share of infrastructure funding. High-class research on the use of nuclear energy requires a modern architecture.

Projects of the SAFIR2018 research programme also enable participation in extensive international research projects and thus obtaining information about research in which we could not otherwise participate. In Finland, a publicly funded safety research programme has traditionally included international nuclear power plant safety research projects that are conducted by authorities in cooperation. The projects have been required to actively participate in implementation of research. This has been a solid principle. The 2015 projects include a new international research project for Finland. The Fukushima Daiichi accident of 2011 is studied in this project. The SAFIR2018 research programme also includes projects that are performed by Finnish laboratories with the help of international cooperation or with the help of international funding. Active participation in international research projects and conducting international experiments in Finland are good and important characteristics of the programme. Results of the SAFIR2018 research programme are public and the programme also implements, in its part, the international programme approved by the IAEA general assembly in September 2011 after the Fukushima Daiichi nuclear accident on global improvement of the safety of the use of nuclear energy (the IAEA Action Plan).

The Nuclear Energy Act was amended in 2015 in such a manner that for the next ten years, licensees are obligated to provide funding for the equipment in the hot chambers of VTT's Centre for Nuclear Safety and rent subsidy for the Centre for Nuclear Safety in addition to the funding they provide for nuclear research projects. The annual charge to be paid to the Finnish State Nuclear Waste Management Fund is EUR 570 for 2016–2020 and EUR 390 for 2021–2025 per one megawatt of rated thermal power given in the licence or one megawatt of the maximum thermal power given in a decision-in-principle or, if a construction licence has been applied based on a decision-in-principle, per one megawatt of rated thermal power given in the licence application. Cancellation of the decision-in-principle for the Olkiluoto 4 nuclear power plant unit of TVO meant that volume of the SAFIR2018 research programme would decrease by 24% from the 2015 level as of the beginning of 2016. The competitive bidding for 2016 and the proposal for the projects to be funded in 2016 were planned taking these boundary conditions into account.

Final report of the KYT2014 research programme was finalised in the spring of 2015. A total of 39 research projects were ongoing during the research period. They were either separate or new projects, or continuation for previous projects. 21 projects were ongoing for the entire duration of the research period. Most of the research projects involved assessment of the safety of nuclear waste management. During the research period, the Finnish State Nuclear Waste Management Fund allocated a total of around EUR 7 million for the research projects. Around EUR 1.7 million was used in research every year (Table 1).

Around 90% of the funding for nuclear waste management research went to safety research, and a little less than a half of this share was allocated to the subject matters of safety cases, performance of buffer and backfilling materials, and long-term durability of canisters. The funding share of alternative technologies has remained at around 7% and the share of social science research at around 2–3%.

During the research period (2011–2014), the research programme's research projects published a total of 50 valuable publications (academic articles), 174 conference publications or work reports and 47 theses, of which six were doctoral theses. A summary of the publications is available in the final report of the KYT2014 programme. KYT2014 programme's concluding seminar was arranged in March 2015.

The four-year KYT2018 research programme was launched in 2015. The programme's key research areas are more or less the same as the KYT2014 programme. The programme consists of research issues important to national expertise. It aims at extensive coordinated research projects. Such have been formed particularly regarding the research areas of performance of buffer and backfilling materials as well as the long-term durability of disposal canisters.

The KYT management group provided its funding recommendations for 2015 to the Ministry of Employment and the Economy based on assessments by the support groups, applicability of the subject matter and content of the research project. In 2015, the total funding of the KYT2018 programme from the National Nuclear Waste Management Fund (VYR) is about EUR 1.9 million. In 2015, the research programme provided funding for 29 research projects representing new and alternative technologies for nuclear waste management (2 projects), safety research on nuclear waste management (26 projects), and social nuclear waste management research (1 project). The most important coordinated research subjects were buffer and backfilling materials, long-term durability of canisters and microbiology. Due to the legislative reform aiming at funding VTT's Centre for Nuclear Safety, annual funding for the KYT2018 programme will decrease to around EUR 1.56 million per year for the remaining years.

Figure 5. Research areas of KYT2018 programme and their shares of the total funding in 2015.

5 Oversight of nuclear facilities in figures

5.1 Processing of documents

A total of 3,138 documents were submitted to STUK for processing in 2015. Of these, 926 concerned the nuclear power plant unit under construction and 115 the disposal facility for spent nuclear fuel. The reviewing process of a total of 3,306 documents was completed, including documents submitted in 2015, those submitted earlier and licences granted by STUK by virtue of the Nuclear Energy Act, which are listed in Appendix 8. The average document review time was 122 days. The number of documents and their average review times in 2011–2015 are illustrated in Figure 6. Figures 7–10 illustrate the

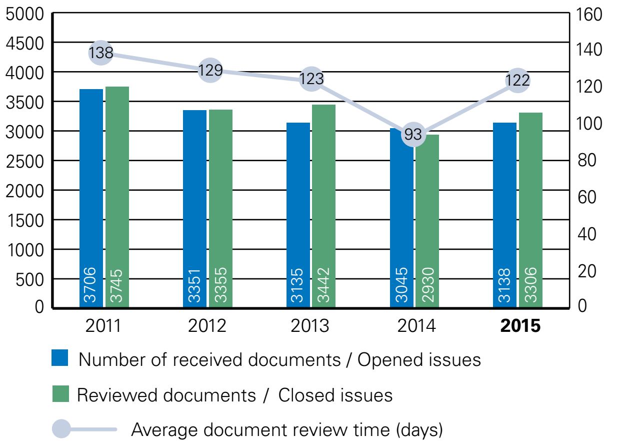


Figure 6. Number of documents received and reviewed as well as average document review time.

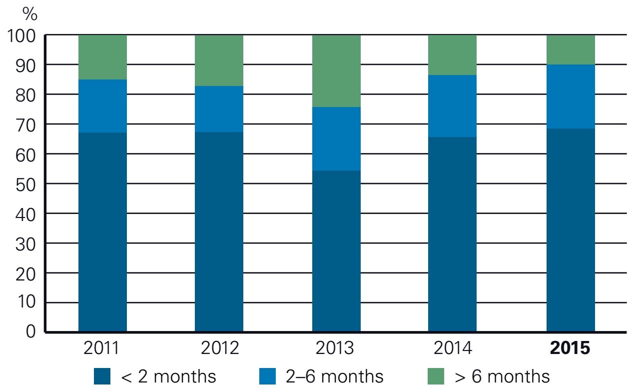


Figure 7. Distribution of time spent on preparing decisions on the Loviisa plant.

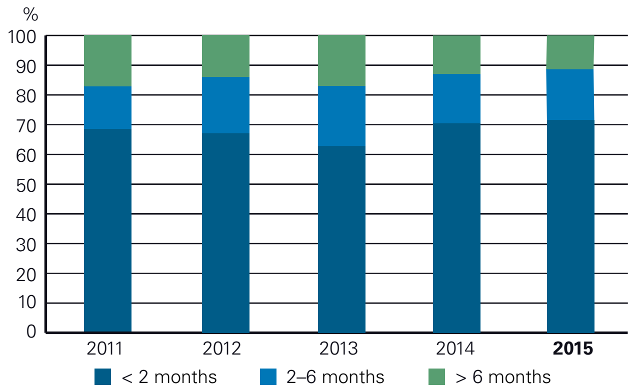


Figure 8. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

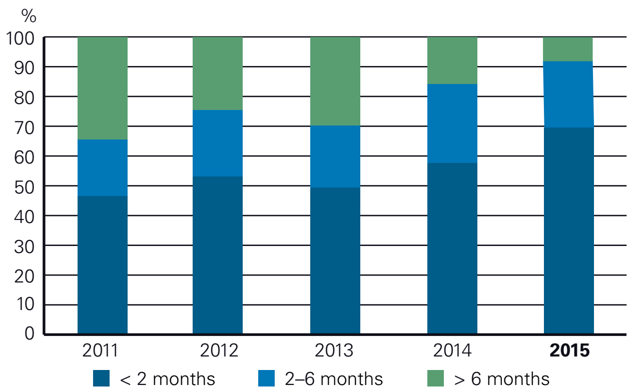


Figure 9. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

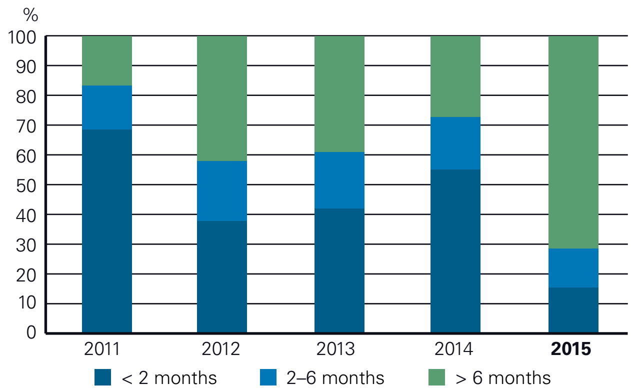


Figure 10. Distribution of time spent on preparing decisions on Posiva.

review time distribution among documents from the various plant units and documents about Posiva.

5.2 Inspections at nuclear power plant sites and suppliers' premises

Inspection programmes

A total of 21 inspections at the Loviisa nuclear power plant and 21 at the Olkiluoto nuclear power plant were carried out under the 2015 periodic inspection programme (Appendix 4). STUK carried out 13 inspections within the Olkiluoto 3 construction inspection programme (Appendix 5) and six inspections pertaining to the processing of Fennovoima construction licence application (Appendix 6). Two inspections of the encapsulation plant and disposal facility construction inspection programme were carried out in 2015 (Appendix 7). The key findings of the inspections are presented in the appendices and the chapters on regulatory oversight.

Other inspections at plant sites

A total of 1,209 inspections onsite or at suppliers' premises were carried out in 2014 (other than the above-mentioned construction inspection programme inspections and nuclear safeguards inspections, which are separately described). An inspection comprises one or more sub-inspections, such as a review of results, an inspection of component or structure, a pressure or leak test, a functional test or a commissioning inspection. Of the inspections, 270 were related to the regulatory oversight of the plant under construction and 939 to that of the units in operation.

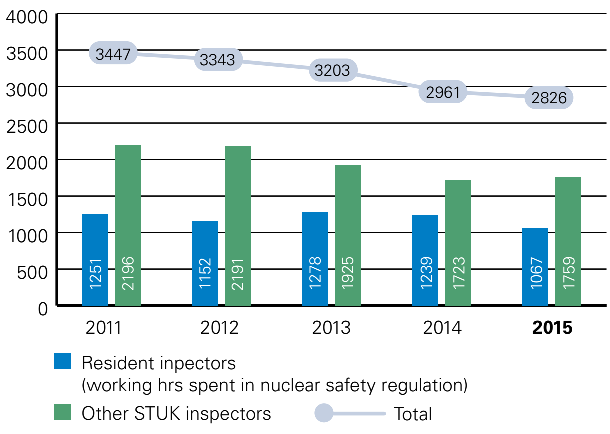


Figure 11. Number of inspection days onsite and at component manufacturers' premises. Overtime work is not included.

The number of inspection days on site and at component manufacturers' premises totalled 2,826. This number includes not only inspections pertaining to the safety of nuclear power plants but also those associated with nuclear waste management and nuclear safeguards as well as audits and inspections of the underground research facility at Olkiluoto. Four resident inspectors worked at Olkiluoto NPP and three resident inspectors at Loviisa NPP. The numbers of onsite inspection days in 2011–2015 are illustrated in Figure 11.

5.3 Finances and resources

The duty area of nuclear safety regulation included basic operations subject to a charge, as well as operations not subject to a charge. Basic operations subject to a charge mostly consisted of the regulatory oversight of nuclear power plants, with their costs charged to those subject to the oversight. Basic operations not subject to a charge included international and domestic cooperation, as well as emergency response operations and communications. Basic operations not subject to a charge are publicly funded. Overheads from the preparation of regulations and support functions (administration, development projects in support of regulatory activities, training, maintenance and development of expertise, and reporting, as well as participation in nuclear safety research) were carried forward into the costs of both types of basic operation and of contracted services in relation to the number of working hours spent on each function.

In 2015, the costs of the regulatory oversight of nuclear safety subject to a charge were EUR 19.4 million. The total costs of nuclear safety regulation were EUR 21.8 million. Thus, the share of activities subject to a charge was 89.0%.

The income from nuclear safety regulation in 2015 was EUR 19.4 million. Of this, EUR 4.5 million and EUR 10.2 million came from the inspection and review of the Loviisa and Olkiluoto NPPs, respectively. In addition to the operating units, the income from Olkiluoto NPP includes income derived from the regulatory oversight of the Olkiluoto 3 construction project. Costs arising from the oversight of the Fennovoima nuclear power plant project amounted to EUR 1.6 million. The regulation of Posiva Oy's operations yielded EUR 2.9 million. Figure 12 shows the annual income and costs from nuclear safety regulation in 2011–2015.

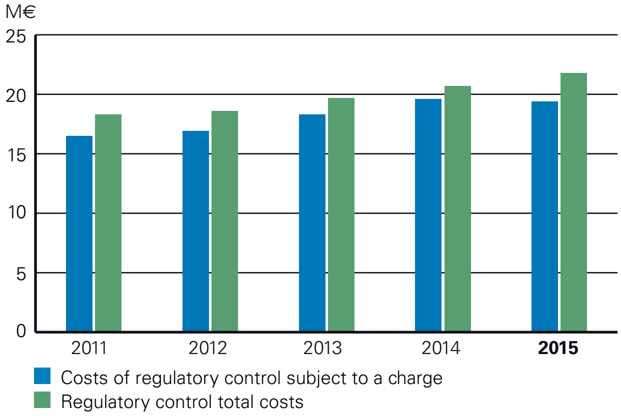


Figure 12. Income and costs of nuclear safety regulation.

The time spent on the inspection and review of Loviisa nuclear power plant was 17.8 man-years, i.e. 11.8% of the total working time of the regulatory personnel. The time spent on the Olkiluoto nuclear power plant's operating units was 16.9 man-years or 11.2% of the total working time. In addition to the monitoring of the operation of the NPPs, these figures include the safeguards of nuclear materials. The time spent on the inspection and review of Olkiluoto 3 was 23.9 man-years or 15.9% of the total working time. Work related to new NPP projects amounted to 6.2 man-years or 4.1% of the total working time. A total of 10.7 man-years or 7.1% of the total working time was spent on inspection and review of Posiva's operations, and that spent on the FiR 1 research reactor was 0.3 man-years. Figure 13 shows the division of working hours of the personnel engaged in nuclear safety oversight (in person-years) by subject of oversight during 2008–2015.

Where necessary, STUK commissions independ-

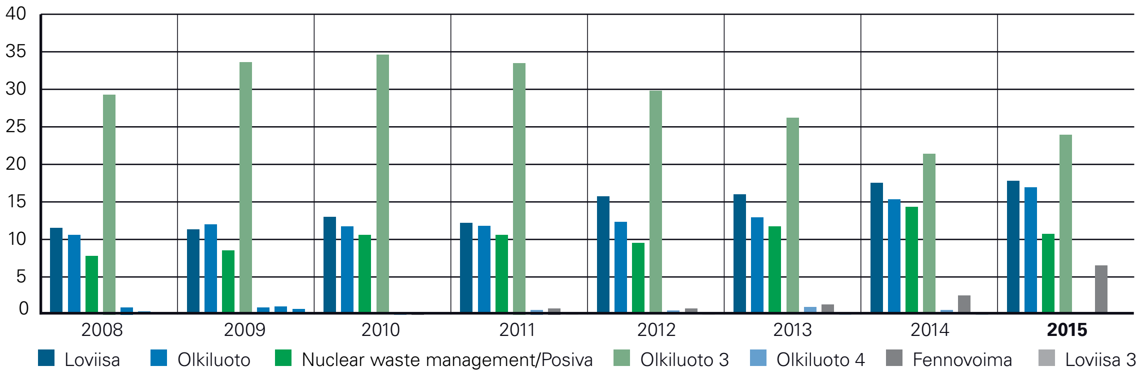


Figure 13. Distribution of working hours (person-years) of the regulatory personnel by subject of oversightin 2008–2015. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012 only the oversight of Posiva. The oversight of the operating nuclear power plants' nuclear waste management is combined with the oversight of the power plants.

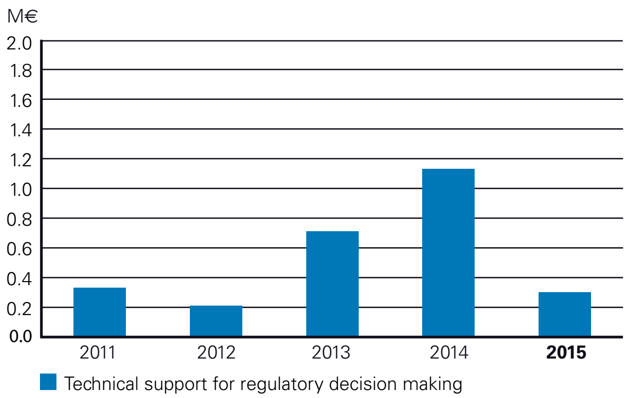


Figure 14. The costs of research and commissioned work pertaining to the safety of nuclear power plants.

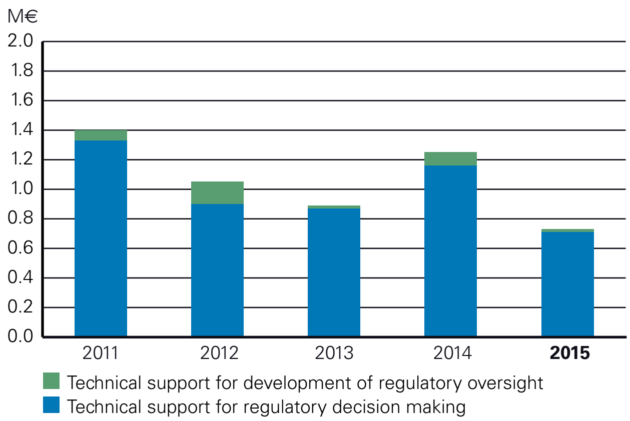


Figure 15. The costs of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

Table 2. Distribution of working hours (person-years) of the regulatory personnel in each duty area.

Duty area	2011	2012	2013	2014	2015
Basic operations subject to a charge	70.2	68.9	69.7	72.0	76.6
Basic operations not subject to a charge	8.8	5.6	5.0	3.5	2.6
Contracted services	1.7	2.2	1.6	2.9	2.8
Rule-making and support functions	43.0	46.3	45.3	41.8	42.2
Holidays and absences	24.7	24.7	25.1	25.3	26.4
Total	148.4	147.7	146.7	145.5	150.5

ent safety analyses and research in support of regulatory decision-making. Figures 14 and 15 illustrate the costs of such assignments in 2011–2015. Expenses in 2015 were mainly related to comparative analysis, independent assessments and third-party consultants' inspection work concerning the unit under construction, as well as to assessment work concerning the safety documentation for disposal of nuclear waste.

Distribution of the annual working time of the nuclear safety regulation personnel to the various duty areas is shown in Table 2.

6 International cooperation

International conventions

In February 2015, STUK participated in an extraordinary diplomatic conference regarding a proposal by Switzerland on amending the Convention on Nuclear Safety. The proposal involved taking into account the severe accidents management in the design of new nuclear power plants and modifications of already operating nuclear power plants. The actual Convention on Nuclear Safety could not be amended, but the diplomatic conference prepared a declaration whose contents correspond to the proposal by Switzerland.

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management requires that a report is presented every three years on how the obligations stated in the Convention are met. STUK's experts presented Finland's national report at the review meeting of the Joint Convention in the spring of 2015. Most important issues in Finland over the course of the past three years have been the construction licence application for the spent nuclear fuel encapsulation and disposal facility, revision of the licence conditions for the Olkiluoto operational waste repository to enable the disposal of small amounts of radioactive waste from the Government, and a comprehensive reform of STUK's nuclear safety requirements.

The reviews for both the reports and the presentations were positive and Finland received particular praise for proceeding with the disposal project in stages and developing the expertise of the organisations participating in waste management. Observed challenges included disposal of specific high activity radiation sources and solutions pertaining to the dismantling of a research reactor.

The plenary session of the review meeting focused on common safety issues that were raised in the country group sessions. More than fifty of such issues were identified. The following were deemed the most important: resources, participation of citizens and their positive attitude towards the waste management operations, provisions for waste management after an accident, and managing decommissioned sealed sources and historical waste. Other discussed issues included possible multinational disposal facilities and development of a nuclear waste convention review process. Furthermore, some modifications of guidelines were approved.

MDEP

The Multinational Design Evaluation Programme (MDEP) was established upon the initiative of the United States nuclear safety authority (Nuclear Regulatory Commission, NRC). It involves fifteen countries with the objective of improving cooperation in the field of the assessment of new nuclear power plants and developing convergent regulatory practices. In addition to the United States of America, the following countries participate in the programme: South Africa, India, United Kingdom, Japan, Canada, China, Korea, France, Sweden, Finland, Turkey, Russia and the United Arab Emirates. In 2015, Hungary joined the programme.

Participants in the programme include only those countries with new nuclear power plants at some stage of assessment by the regulatory authorities. The OECD Nuclear Energy Agency functions as the secretariat for the programme. The MDEP's work is organised in design-specific and issue-specific Nuclear Reactor Regulation working groups. In addition, the MDEP has a management group and a steering group. Petteri Tiippana, the Director General of STUK, is the chair of the management group.

There are five Design-Specific Working Groups: the EPR Working Group, the AP1000 Working Group, the APR1400 Working Group, the VVER Working Group and the ABWR Working Group. Of these, STUK has participated in the EPR Working Group and the VVER Working Group, because an EPR plant is under construction at Olkiluoto (the Olkiluoto 3 project) and Fennovoima has submitted a construction licence application on construction of a VVER plant in Pyhäjoki (the Hanhikivi 1 project).

The MDEP Working Groups independent of plant design deal with the following three subjects: plant and plant supplier inspections and reviews, pressure equipment standards and programmable I&C. STUK participated in the activities of all three Issue-Specific Working Groups.

Cooperation within the IAEA

IAEA continued with the revision of its regulatory guides on nuclear safety and the utilisation of radiation, which started in 2009. STUK had representatives on the Commission on Safety Standards (CSS) managing the preparation of the regulatory guides as well as in the committees dealing with the content of the regulatory guides, i.e. the Nuclear Safety Standards Committee (NUSSC), the Waste Safety Standards Committee (WASSC), the Radiation Safety Standards Committee (RASSC), the Nuclear Security Guidance Committee (NSGC), the Transport Safety Standards Committee (TRANSSC) and the Emergency Preparedness and Response Standards Committee (EPReSC). By working in the committees, STUK actively participated in development of IAEA's guides. STUK held presentations regarding application of the IAEA guides in the Finnish regulations at both the NUSCC and the WASSC. In addition to the IAEA Nuclear Security Guidance Committee (NSGC), an expert of STUK was named in the Advisory Committee on Nuclear Security to the Director General of the IAEA (AdSec) for the term 2013–2015.

Representatives of STUK were included in expert groups summoned by the IAEA; the groups reviewed the regulatory authorities' operations in Switzerland, India, Slovakia and Hungary, and participated in international peer reviews of security arrangements in Japan and Canada.

IAEA's International Training Course on the Preventive and Protective Measures against Insider Threat was arranged in Finland. STUK hosted the course and acted as the trainer.

Cooperation within the OECD/NEA

The Nuclear Energy Agency of the OECD (NEA) coordinates international cooperation in the field of safety research in particular. The organisation also provides an opportunity for cooperation between regulatory authorities. STUK was represented in all main committees of the organisation dealing with radiation and nuclear safety issues. The main committees' fields of activity are:

- Nuclear safety regulation (CNRA, Committee on Nuclear Regulatory Activities)
- Safety research (CSNI, Committee on the Safety of Nuclear Installations)
- Radiation safety (CRPPH, Committee on Radiation Protection and Public Health)
- Nuclear waste management (RWMC, Radioactive Waste Management Committee).

In September, STUK arranged in Helsinki in cooperation with the Ministry of Employment and the Economy and the NEA/RWMC an international meeting on challenges faced by authorities in the disposal of nuclear waste. More than seventy people participated in the meeting. These included representatives of advanced countries and countries that are just planning their projects. Finnish nuclear waste management was well represented in the meeting agenda.

Cooperation within the EU

WENRA

STUK actively participated in the work of WENRA's Reactor Harmonisation Working Group (RHWG) and Working Group on Waste and Decommissioning (WGWD) in 2015. WENRA published new reference levels, updated based on lessons learned from the Fukushima accident, in late 2014. In 2015, STUK conducted a self-assessment on coverage of national regulations when it comes to the reference levels and prepared a national plan on implementation of missing reference levels. Over the course of the year, WGWD finalised a reference level report regarding decommissioning, started self-assessments and peer assessments of disposal reference levels, and started the preparation of a reference level report for nuclear waste treatment facilities.

ENSRA

STUK participated in one meeting of the European Nuclear Security Regulators' Association (ENSRA).

ENSREG

STUK participated in the activities of the European Nuclear Safety Regulators Group (ENSREG) and in three of its subgroups (nuclear safety, nuclear waste management and communication). In July 2015, STUK prepared and submitted to the European Commission a report on compliance with the Nuclear Waste Directive and participated, with the Ministry of Employment and the Economy, in preparation of a national programme for management of spent nuclear fuel and other forms of radioactive waste.

As a result of the Fukushima accident, the EU launched stress tests for existing nuclear power plants and for those under construction. The purpose of these tests was to establish how the NPPs would cope with exceptional external events and other situations associated with the simultaneous loss of operability of several safety systems. In late 2014, STUK updated the national action plan of Finland, which was reviewed by a review meeting arranged by the ENSREG in Brussels in April 2015.

Bilateral cooperation

STUK started regular cooperation with the French nuclear safety authority Autorité de Sûreté Nucléaire (ASN) and its support organisation Institut de Radioprotection et de Sûreté Nucléaire (IRSN) when the Olkiluoto 3 project was launched in the early 2000s. Regulatory practices and statutory requirements of the countries have been compared, and challenges and problems pertaining to the EPR plants under construction in both countries (Olkiluoto 3 and Flamanville 3) have been discussed.

Cooperation with the Russian nuclear safety authority Rostechnadzor (RTN) regarding safety assessments of AES2006-type VVER plants (Fennovoima's Hanhikivi 1 as well as units 1 and 2 of the Leningrad 2 nuclear power plant in Russia, for instance) has also been started. In 2015, a meeting was held where RTN presented results of an assessment of the construction and operating licence for the new units in Leningrad and STUK presented results of the decision-in-principle phase safety assessment for Hanhikivi 1. Furthermore, events have been arranged with RTN where local inspection activities at the units under construction in both countries have been studied.

The Hungarian radiation and nuclear safety authority HAEA has also started preparation for a safety assessment of an AES-2006 nuclear power plant (PAKS-2 plant). In 2015, the necessary prerequisites for bilateral cooperation between STUK and the HAEA were achieved. STUK also agreed on starting cooperation with the Turkish nuclear safety authority TAEK.

APPENDIX 1 Objects of regulation

Loviisa nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb1977	9 May 1977	520/496	Pressurized water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	520/496	Pressurized water reactor (PWR), Atomenergoexport

Fortum Power and Heat Oy owns the Loviisa 1 and 2 plant units located in Loviisa.

Olkiluoto nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct 1979	910/880	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	910/880	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	Construction license granted 17 Feb 2005		Approx. 1,600 (net)	Pressurized water reactor (PWR), Areva NP

Teollisuuden Voima Oyj owns the Olkiluoto 1 and 2 plant units located in Olkiluoto, Eurajoki, and the Olkiluoto 3 plant unit under construction.

Hanhikivi nuclear facility project

Plant unit	Supplemented Decision-In-Principle approved	Nominal electric power, net (MW)	Type, supplier
Hanhikivi 1	5 Dec 2014	Approx. 1200	Pressurised Water Reactor (PWR), ROSATOM

Hanhikivi nuclear power plant FH1 is a power plant project of Fennovoima.

Olkiluoto encapsulation plant and disposal facility

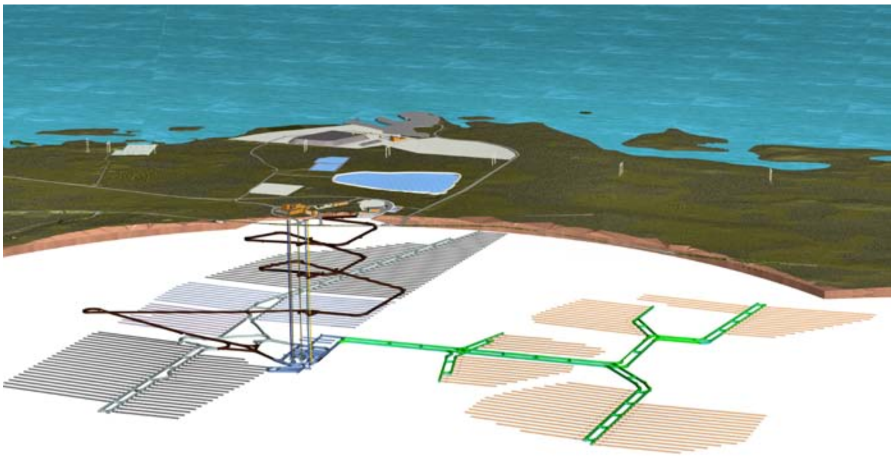
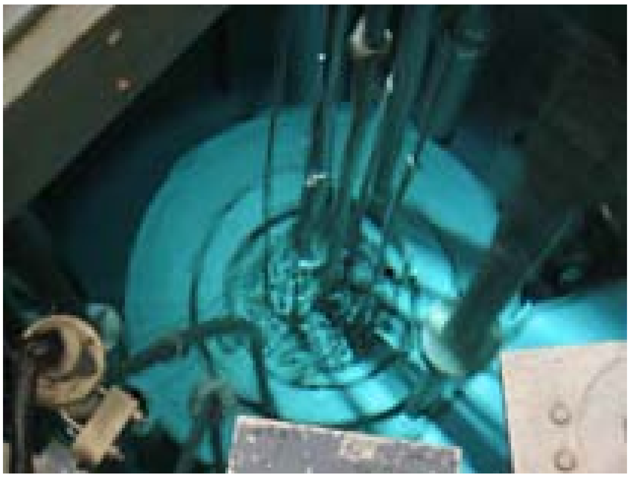


Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

In November 2015, the Government granted Posiva a construction licence for the Olkiluoto encapsulation plant and disposal facility. The planned facility consists of a surface facility for the encapsulation of spent nuclear fuel, an underground disposal facility, and supporting buildings. Posiva has already built an access tunnel, three shafts and a technical facility and research area at a depth of 420–437 metres as parts of the underground research facility Onkalo. For the actual disposal facility, the underground facility will be expanded by two additional shafts and the disposal tunnels that will be excavated in stages. The construction of an underground research facility was a prerequisite for granting a construction licence. Onkalo will provide an opportunity for more detailed study of the rock volumes best suited for the disposal of spent nuclear fuel, and allow for the testing of disposal facility construction methods and installation of the disposal system components.

FiR 1 research reactor



Facility	Thermal power	In operation	Fuel	TRIGA-reaktorin polttoainetyyppi
TRIGA Mark II research reactor	250 kW	March 1962–June 2015	Reactor core consists of 80 fuel rods which contain 15 kg of uranium	Uranium–zirkonium-hybrid combination: 8% uranium 91% zirkonium and 1% hydrogen

The FiR 1 research reactor, operated by VTT Technical Research Centre of Finland, was commissioned in March 1962. VTT stopped using the reactor in June 2015 and placed in permanent shutdown. VTT is preparing an application on revising the reactor operating licence.

Other uses of nuclear energy

The regulation also applies to mining and any preparation of ore aiming at obtaining uranium or thorium. Such operations are practiced at the production plants of Norilsk Nickel Harjavalta Oy and Freepoint Cobalt Oy. A planned uranium preparation plant at Talvivaara is also part of this regulatory group. There are small amounts of regulated materials at some laboratories. The regulation also applies to nuclear equipment, systems and nuclear information as well as nuclear fuel cycle research and development activities and the transport of nuclear materials and nuclear waste.

APPENDIX 2 STUK's safety performance indicators for NPP's in 2015

Summary of the safety performance indicators for nuclear power plants

Background and objectives of the indicator system

Safety is a primary prerequisite for the operation of nuclear power plants. The power companies and STUK evaluate and oversee the safety and operation of the plants in many ways. Along with inspections and safety assessments, indicators are a method of acquiring information on the safety level of the NPPs and on any changes to the safety level.

The objective of the indicator system is to recognise changes in plant safety as early on as possible. If the indicators weaken, the underlying factors influencing the development must be determined and changes to plant operation and STUK's oversight of the area must be considered. Indicators can also be used to monitor the efficiency and effectiveness of corrective measures. Furthermore, the information yielded by the indicators is used when communicating nuclear safety.

In the indicator system, nuclear safety is divided into three sectors: 1) operation and maintenance, 2) operational events and 3) structural integrity. STUK began the development of its own indicator system in 1995. Since 2006, indicator information has been managed in STUK's INDI (INdicator DIsplay) information system. Nominated STUK representatives are responsible for the maintenance and analysis of the indicators. Individual indicators, their maintenance procedures and the interpretation of results are presented at the end of this summary. A brief summary of the safety status of each plant in 2015 is given below, followed by detailed results by indicator.

<table>
<tr><th colspan="3">Nuclear safety</th></tr>
<tr><th>A.I Operation and maintenance of a nuclear facility</th><th>A.II Operational events</th><th>A.III Structural integrity</th></tr>
<tr><td>1. Failures and their repairs</td><td>1. Number of events</td><td>1. Fuel integrity</td></tr>
<tr><td>2. Exemptions and deviations from the Operational Limits and Conditions</td><td>3. Risk-significance of events</td><td>2. Primary and secondary circuits integrity</td></tr>
<tr><td>3. Unavailability of safety systems</td><td>4. Accident risk of nuclear facilities</td><td rowspan="4">3. Containment integrity</td></tr>
<tr><td>4. Occupational radiation doses</td><td rowspan="3">5. Number of fire alarms</td></tr>
<tr><td>5. Radioactive releases</td></tr>
<tr><td>6. Investments in facilities</td></tr>
</table>

Operation and maintenance *are assessed on the basis of information concerning the radiation protection and the operation and maintenance of the plant. The operation and maintenance of the plant is monitored using the failure and maintenance data for the components with an effect on the safe operation of the plant, as well as by monitoring compliance with the operational limits and conditions (OLC). The success of radiation protection is monitored on the basis of the employees' radiation doses and radioactive releases into the environment. Attention is also paid to investments to improve the plant and to the up-to-dateness of the plant documentation.*

The indicators concerning ***operational events*** *are used to monitor special situations and significant disturbances at the plant. Special situations include events with an effect on the safety of the plant, the personnel or the environment. A special report is required for any special situations. Correspondingly, a transient report must be prepared for any significant disturbances occurring at a plant unit. Such transients include reactor and turbine trips, and other operational transients leading to a forced reduction of more than 5% in the reactor power or average gross power. Risk indicators are used to monitor the safety effect of component unavailability and development of the plant's risk level. The results provide insight into the operational activities at the plant and the efficiency of the operating experience feedback system.*

Structural integrity *is assessed on the basis of the leak-tightness of the multiple radioactivity confinement barriers – the fuel, primary and secondary circuits, and the containment. The integrity must meet the set objectives while the indicators must show no significant deterioration. Fuel integrity is monitored on the basis of the radioactivity of the primary coolant and the number of leaking fuel bundles. The water chemistry indicators are used to monitor and control the integrity of the reactor coolant system and the secondary circuit. The monitoring is done by indices depicting the maintenance of water chemistry and by following selected corrosive impurities and corrosion products. Integrity of the containment is monitored by testing the leak tightness of isolation valves, penetrations and air locks.*

Results of the safety performance indicators for the nuclear power plants in 2015

Summary of indicator results for Loviisa NPP

Total number of maintenance tasks on components subject to the OLC (+6.2%), preventive maintenance (+3.5%) and fault repairs (+22.9%) have all slightly increased from the previous years. Even though the number of fault repairs has increased relatively the most, the ratio between preventive maintenance and fault repairs (5.4) still indicates that the share of preventive maintenance of all maintenance work has remained high. Faults in components subject to the OLC that are important to safety and the number of operation restrictions due to such faults have remained at the same level as in the previous years. In the case of potential common-cause failures, one potential operational event was identified at the Loviisa power plant in 2015. It involved relays in safety class 2 rectifiers where software common-cause failure could not be completely ruled out. The number of faults resulting in production losses remained low, as in the previous years. Detection and anticipation of faults have been continuously improved in the maintenance operations of Loviisa nuclear power plant and components have been replaced, which is why there have been no faults that have a major impact on the safe operation of the plants. The average repair times of faults causing inoperability of components subject to the OLC have become shorter, i.e. the development has been positive. The power company still needs pay attention to having the necessary resources available for fault repairs, and to carrying out the repairs without unnecessary delays. Based on the indicators, ageing management and component maintenance at the Loviisa nuclear power plant have been functional and the development measures taken have been correct.

The main purpose of the OLC exemption procedure is to enable modifications and maintenance that will improve safety and plant availability with the approval of STUK. In 2015, the Loviisa NPP submitted six exemption applications to STUK for approval. This is a normal number of applications. Furthermore, the plant was in a state that was non-compliant with the OLC five times in 2015. These events are described in more detail in Appendix 3. They were isolated events and their safety significance was low. Fortum has prepared operating experience reports regarding the events and determined corrective measures.

In the STUK indicator system, the functionality of safety systems is monitored on the basis of the unavailability of the high-pressure safety injection system, emergency feedwater system and emergency diesel generators. As in previous years, condition and availability of the emergency feedwater systems were high in 2015. Availability of the emergency diesel generators slightly improved from the previous years and remained at an acceptable level.

The main part of the radiation doses is received during outages. Due to improvements in radiation safety, the radiation doses of employees have decreased, and the collective occupational dose in 2015 was the lowest ever recorded. The radiation doses for employees at the Loviisa NPP remained below the individual dose limits. In 2015, the average of the ten largest doses was clearly lower than the average for the previous years. The threshold set for the collective occupational dose was not exceeded either. In 2015, radioactive releases into the air and water from the Loviisa NPP were slightly smaller than in the previous years. The releases remained clearly below the limits set. Assessment of the radiation dose of the most exposed individual in the vicinity of a nuclear power plant is based on information about the NPP's releases and meteorological measurements. The exposure routes that are taken into account include external radiation and internal radiation, i.e. radiation caused by radioactive materials ending up inside the body via air or food. In 2015, the radiation doses of the most exposed individual in the vicinity of the Loviisa NPP were normal. The radiation doses were less than 0.1% of the limit set in the Government Decree (100 µSv). According to the indicators, radiation safety is good and being developed in a determined manner.

Operational events

No reactor trips occurred at the Loviisa nuclear power plant in 2015. The number of transient reports remained at the normal level (3). The number of events warranting a special report slightly increased (5), but the safety significance of the events was low. The NPP submitted a total of 13 operational event reports in compliance with the new Guide YVL A.10. In addition to special reports and transient reports, these reports include other plant events submitted to STUK for information.

The indicator for risk-significance of component unavailability is an increase of the conditional core damage probability (CCDP) in connection with each event. In 2015, this indicator was of the same magnitude as in the previous year when taking into account events that are most significant in terms of the risk. The number of risks due to operational activities has continued to decrease over the past four years, however.

Loviisa NPP's accident risk has continued to decrease over the last ten years, and new risk factors, discovered as the scope of the PRA has been extended, have been efficiently eliminated. At the end of 2015, the annual probability of core damage at Loviisa 1, calculated with the PRA model, was 26% lower than in 2014, and the annual probability of core damage at Loviisa 2 was 20% lower than in 2014. The difference between the plant units' risk assessments is due to differences in ventilation and air conditioning systems that contain safety systems, for example. The risk has decreased from the previous year mainly because of new cooling towers that were commissioned in 2015. They allow for the removal of residual heat in the long term also if seawater cooling is lost. No events classified as fires occurred at the Loviisa nuclear power plant in 2015. The rescue personnel had one assignment in the parking area, which is located outside the actual power plant area: they had to extinguish a smouldering passenger vehicle. The number of fire detection system faults at the Loviisa NPP has remained at the same level for the past ten years.

Structural integrity

There was no leaking fuel in the reactors of the Loviisa units in 2015, which means that the maximum iodine (I-131) activity value of the primary coolant remained low. In the past few years, the chemistry index has also remained at a good level at the Loviisa plant units. In 2015, the maximum Co-60 activity levels associated with shutdowns were around the same as in the previous years, which indicates successful compliance with the ALARA principle. All of the chemistry indicators show that the integrity of the reactor coolant systems at the Loviisa plant units was good in 2015.

Integrity of the containment has remained good at both plant units. Total leakage of the outer isolation valves has remained the same as before and the total as-found leakage rate has remained clearly below the set limit at both plant units. Furthermore, the number of isolation valves that passed the leak test at first attempt has increased in both plant units. Overall as-found leakage rate of containment penetrations and airlocks is low at both plant units.

According to the indicators, the plant's fuel, primary circuit and containment integrity are good.

Summary of indicator results for Olkiluoto NPP

Operation and maintenance

In 2015, the number of fault repairs that caused inoperability of components remained at the same level as in the previous years. The number of preventive maintenance operations somewhat increased at Olkiluoto 1 and decreased by half at Olkiluoto 2. Based on the development of the ratio of preventive maintenance work to fault repairs and an assessment of the work on which the figures are based, the maintenance strategy can be considered successful even though the value for 2015 at Olkiluoto 2 was the lowest in the past few years (0.65). The number of faults occurring during load operation that cause unavailability of components subject to the operational limits and conditions (OLC) remained at around the 2014 level in 2015. The unavailability times of OLC components were short. At OL1, the number of immediate operation restrictions and operation restrictions starting at the beginning of the repair work remained at the same level as in the previous years. When compared to 2014, immediate operations restrictions decreased by half at Olkiluoto 1 but increased at Olkiluoto 2. The observed faults in OLC components did not occur in a particular system alone. In 2015, the average repair time of failures causing the unavailability of components subject to the operational limits and conditions (OLC) was around seven hours at both plant units. This is around the long-term average and at around the same level as in the previous years. Based on the 2015 indicators and the data on which they are based, ageing management, maintenance and fault repairs of components important to safety at the Olkiluoto nuclear power plant have been appropriate.

The main purpose of the OLC exemption procedure is to enable modifications and maintenance that will improve safety and plant availability with the approval of STUK. In 2015, TVO submitted seven exemption applications to STUK for approval. This is a normal number of applications. Furthermore, the plant was in a state that was non-compliant with the OLC five times in 2015. These events are described in more detail in Appendix 3. TVO has submitted operational event reports regarding all the events to STUK for approval. In these reports, the causes of the events are analysed and corrective measures are determined. Unintentional deviations from the OLC did not compromise nuclear or radiation safety.

Functionality of safety systems is monitored on the basis of the unavailability of the containment spray system, the auxiliary feedwater system and the emergency diesel generators. The condition and availability of safety injection systems and emergency diesel generators were good in 2015.

Radiation doses received by employees and releases into the environment remained low and clearly below the limits set in official regulations. The collective occupational dose of the employees of Olkiluoto NPP was higher in 2015 than in 2012–2014, but lower than the prevailing level before 2012. In 2015, the average of the ten largest doses was the second lowest ever recorded during the operation of the plant. The radiation doses have clearly decreased after the installation of new moisture separators in 2005–2007. The radiation level in the turbine buildings has continued to decrease after the installation of the moisture separators, which has also decreased the collective occupational dose. Furthermore, improvements aiming at reducing the employees' radiation doses have also been made in radiation protection of the NPP.

The releases of substances with gamma activity into the sea from Olkiluoto have decreased in recent years. In 2015, releases of radioactive materials into the air were of the same magnitude as in the preceding years. Releases into the environment were low, well below the set limits. Assessment of the radiation dose of the most exposed individual in the vicinity of a nuclear power plant is based on information about the NPP's releases and meteorological measurements. The exposure routes that are taken into account include external radiation and internal radiation, i.e. radiation caused by radioactive materials ending up inside the body via air or food. In 2015, the radiation doses of the most exposed individual in the vicinity of the Olkiluoto NPP were normal. The radiation doses were less than 0.1% of the limit set in the Government Decree (100 µSv). Based on the indicators, radiation safety at Olkiluoto has been appropriately arranged.

Operational events

No reactor trips occurred at the Olkiluoto nuclear power plant in 2015. The plant submitted a total of five transient reports, which is a normal amount. The number of events warranting a special report slightly increased (5), returning to the level of 2012. The most important events are described in Appendix 3. TVO analysed the events and defined corrective measures to prevent recurrence of the events. The NPP submitted a total of 18 operational event reports in compliance with the new Guide YVL A.10. In addition to special reports and transient reports, these reports include other plant events submitted to STUK for information.

The indicator for risk-significance of component unavailability is an increase of the conditional core damage probability (CCDP) in connection with each event. In 2015, this indicator for the Olkiluoto plant units was slightly higher than in the previous years when taking into account events that are most significant in terms of the risk. In addition to preventive maintenance of diesel generators, key issues were single failures in the core spray system 323 and the emergency feedwater system 327. The number of risks due to operational activities remained at around the same level as in the previous years, however.

Accident risk was around the same as in 2014 for both of the Olkiluoto plant units. The minor changes in core damage frequency are due to specifications made in the PRA models and updated reliability information. The difference between the plant units is mainly caused by the fact that Olkiluoto 1 underwent modifications in 2014 that ensured operability of the auxiliary feedwater system, which is used to cool the reactor, in case seawater cooling is lost because of a blockage at the seawater intake or component failures. Such modifications have not been implemented at Olkiluoto 2 yet.

No events classified as fires occurred at the Olkiluoto nuclear power plant (OL1/OL2) in 2015.

Three events classified as fires occurred outside the plant area, at the Olkiluoto 3 plant unit construction site. The fire events were minor and the fires could be extinguished with a dry powder extinguisher.

No fire detection system faults were observed at the Olkiluoto NPP (OL1/OL2) in 2015. Correct alarms of the fire detection system have remained at a fairly low level over the past ten years.

Structural integrity

Based on water chemistry indicators, integrity of the reactor coolant systems at the Olkiluoto plant units was good in 2015. There were no leaking fuel assemblies in the reactors of Olkiluoto 1 and Olkiluoto 2 in 2015. This is reflected in the fact that the maximum iodine (I-131) activity value of the primary coolant has reduced at Olkiluoto 1 since 2011 and at Olkiluoto 2 since 2014. The impurity and corrosion product levels in reactor water and feedwater remained below the OLC limits at both plant units. In 2015, the chemistry index for Olkiluoto 1 was the best possible or 1. The chemistry index at Olkiluoto 2 was higher due to a condenser seawater leak. The plant units' reactor water iron, sulphate and chloride contents were normal in 2015. There were no essential changes in the Co-60 activity concentration which is connected to shutdowns when compared to previous years. This indicates successful compliance with the ALARA principle.

The reactor coolant system was relatively leak-proof during the 2014–2015 fuel cycle. At Olkiluoto 1, controlled and unidentified leaks remained at the low level of the previous years. The level was higher at Olkiluoto 2 in 2014 and 2015. The number of unidentified leaks in the primary circuit decreased to around half of the 2014 level at Olkiluoto 2, however. The ratio of the largest daily leak volume within the containment to the maximum leakage allowed in the OLC was low at both plant units, as in the previous years (0.7% and 2.3%). The total as-found leakages of outer isolation valves at both plant units remained clearly below the limit set in the OLC. The percentage of isolation valves that passed the leak test at first attempt has remained high for both plant units. Total as-found leakage rate of penetrations (such as personnel airlocks) has remained low at both plant units.

According to the indicators, the plant's fuel, primary circuit and containment integrity are good.

Safety performance indicators

A.I Operation and maintenance

A.I.1 Faults and repairing them

A.I.1a Faults in components subject to the OLC

Definition

The number of faults causing the unavailability of components during load operation defined in the operational limits and conditions (OLC) is monitored as an indicator. The faults are divided by plant unit into two groups: faults causing an immediate operation restriction, and faults causing an operation restriction in connection with repair work.

Source of data

The data is obtained from the work order systems and the operational documents of NPPs.

Purpose

The indicator is used to assess nuclear power plant lifecycle management and development of the condition of components.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

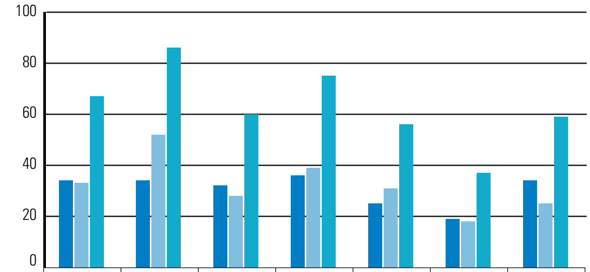
Interpretation of the indicator

Loviisa

The total number of faults causing an operation restriction of components subject to the OLC in 2015 was 186. The average number of faults during the four previous years was 167, which means that there was no significant change in the number of faults in 2015 or in the fault trend.

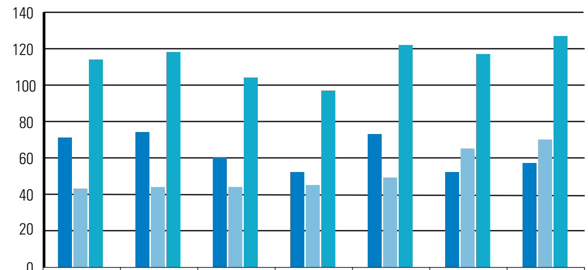
The number of faults per year remained stable. Any variation therein has been caused by the random occurrence of faults that occurs in any large number of components. Fault detection and anticipation have been continuously improved in plant maintenance operations at Loviisa, and components have been replaced. Due to these measures, there have been no faults with a significant impact

Number of failures of OLC components causing immediate operation restriction, Loviisa NPP



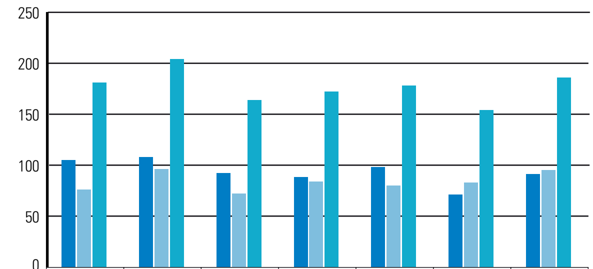
	2009	2010	2011	2012	2013	2014	2015
LO1	34	34	32	36	25	19	34
LO2	33	52	28	39	31	18	25
LO1,2	67	86	60	75	56	37	59

Number of failures of OLC components causing operation restriction from start of a repair work, Loviisa NPP



	2009	2010	2011	2012	2013	2014	2015
LO1	71	74	60	52	73	52	57
LO2	43	44	44	45	49	65	70
LO1,2	114	118	104	97	122	117	127

Number of failures of OLC components causing unavailability during power operation, Loviisa NPP



	2009	2010	2011	2012	2013	2014	2015
LO1	105	108	92	88	98	71	91
LO2	76	96	72	84	80	83	95
LO1,2	181	204	164	172	178	154	186

on plant safety, and the management of component availability has been successful.

Based on the above, it can be stated that the indicator or the underlying fault data do not show any significant negative effects associated with the ageing of the facilities, which is an indication of well-functioning component lifecycle management and component maintenance.

Interpretation of the indicator

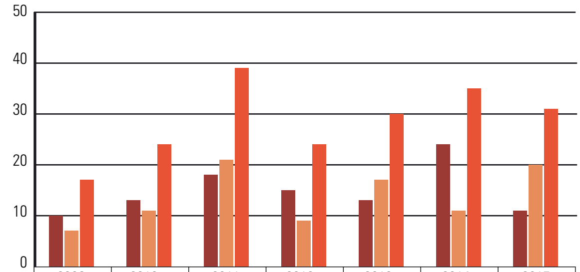
Olkiluoto

The number of faults occurring during load operation and causing the unavailability of components subject to the OLC has been increasing since 2009. In 2011, the number of faults was nearly double the number of faults in 2009. In 2012, the number of faults decreased back to the level of 2010, and the number of faults did not change in 2013 or 2014. According to this indicator, the year 2015 was similar to the year 2014. The number of faults indicates that maintenance has been successful.

The unavailability times of OLC components in OL1 during all four quarters of 2015 were brief. Number of faults leading to an immediate operation restriction at OL1 somewhat decreased from 2014.

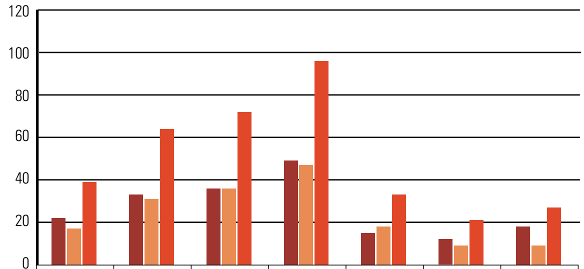
In OL2, most of the unavailability times of OLC components were brief in 2015. Furthermore, the observed faults in OLC components did not occur in a particular system alone.

Number of failures of OLC components causing immediate operation restriction, Olkiluoto NPP



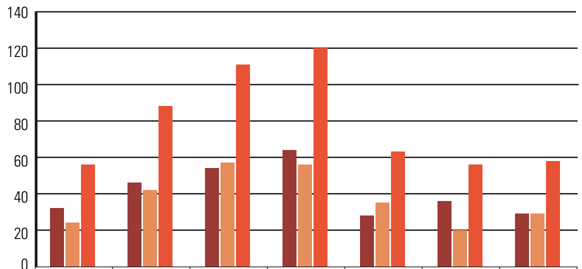
	2009	2010	2011	2012	2013	2014	2015
OL1	10	13	18	15	13	24	11
OL2	7	11	21	9	17	11	20
OL1,2	17	24	39	24	30	35	31

Number of failures of OLC components causing operation restriction from start of a repair work, Olkiluoto NPP



	2009	2010	2011	2012	2013	2014	2015
OL1	22	33	36	49	15	12	18
OL2	17	31	36	47	18	9	9
OL1,2	39	64	72	96	33	21	27

Number of failures of OLC components causing unavailability during power operation, Olkiluoto NPP



	2009	2010	2011	2012	2013	2014	2015
OL1	32	46	54	64	28	36	29
OL2	24	42	57	56	35	20	29
OL1,2	56	88	111	120	63	56	58

A.I.1b Maintenance of components subject to the OLC

Definition

The indicator is used to follow the number of fault repairs and preventive maintenance work orders for components subject to the operational limits and conditions (OLC) by plant unit.

Source of data

The data is obtained from the NPP work order systems, from which all preventive maintenance operations and fault repairs are retrieved.

Purpose

The indicator describes the volumes of fault repairs and preventive maintenance, and illustrates the condition of the NPP and its maintenance strategy. The indicator is used to assess the maintenance strategy implemented at the NPP.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

Interpretation of the indicator

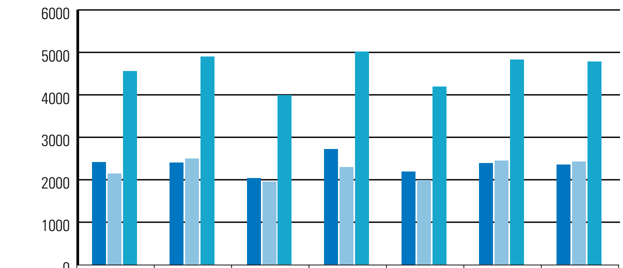
Loviisa

When considering the annual variation in the volume of fault repairs and particularly in the number of preventive maintenance jobs, the scheduling of various annual outages (refuelling outage, short annual outage, four-year annual outage, eight-year annual outage) included in the maintenance strategy of the Loviisa NPP during a four-year cycle should be considered, since it can have a significant impact on the annual figures. In 2015, a short annual outage (a refuelling outage) was implemented at both LO1 and LO2.

According to the data on which the indicator is based, the year 2015 showed no major deviation from the average numbers of fault repairs and preventive maintenance volumes of the four previous years. In 2015, the number of maintenance tasks on components subject to the OLC was 6.2% higher than the average. The volume of preventive maintenance was 3.5% higher than the average, and the number of fault repairs 22.9% higher.

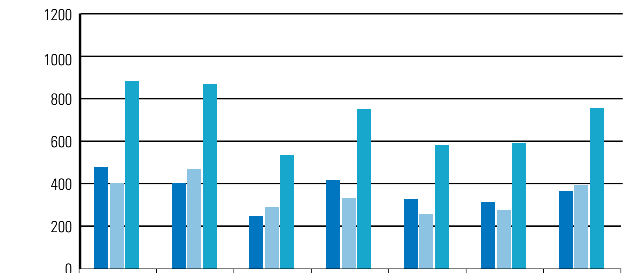
The ratio of preventive maintenance to fault repairs was 5.4. The ratio is 16.4% lower than the 6.4 average of the four previous years, which

Volume of annual maintenance works of OLC components, Loviisa NPP



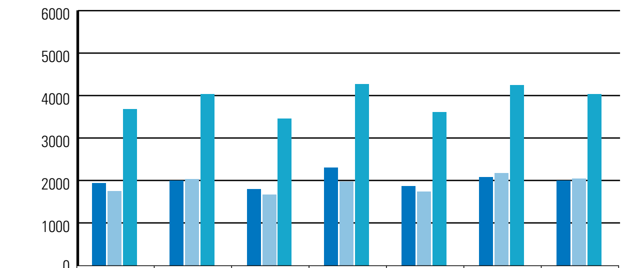
	2009	2010	2011	2012	2013	2014	2015
LO1	2416	2403	2040	2717	2192	2388	2355
LO2	2148	2495	1952	2299	1997	2447	2431
LO1,2	4564	4898	3992	5016	4189	4835	4786

Number of annual failure repair works of OLC components, Loviisa NPP



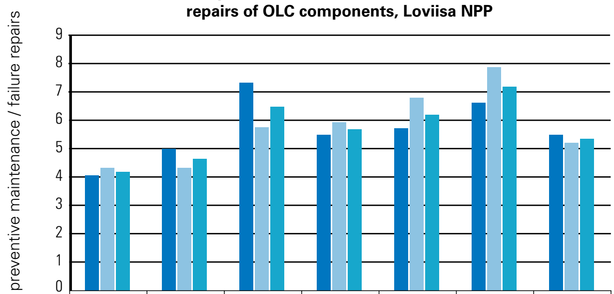
	2009	2010	2011	2012	2013	2014	2015
LO1	478	401	245	419	326	314	363
LO2	404	469	289	332	256	276	392
LO1,2	882	870	534	751	582	590	755

Number of annual preventive maintenance works of OLC components, Loviisa NPP



	2009	2010	2011	2012	2013	2014	2015
LO1	1938	2002	1795	2298	1866	2074	1992
LO2	1744	2026	1663	1967	1741	2171	2039
LO1,2	3682	4028	3458	4265	3607	4245	4031

Ratio of preventive maintenance works to failure repairs of OLC components, Loviisa NPP



	2009	2010	2011	2012	2013	2014	2015
LO1	4.05	4.99	7.33	5.48	5.72	6.61	5.49
LO2	4.32	4.32	5.75	5.92	6.8	7.87	5.20
LO1,2	4.17	4.63	6.48	5.68	6.2	7.19	5.34

means that the share of preventive maintenance of all maintenance work has remained at almost the same level as in the previous years.

The large share of preventive maintenance operations reflects the selected maintenance strategy, the purpose of which is to keep the number of faults and the effects of faults at a tolerable level.

The large share of preventive maintenance operations reflects the selected maintenance strategy, the purpose of which is to keep the number of faults and the effects of faults at a tolerable level.

Interpretation of the indicator

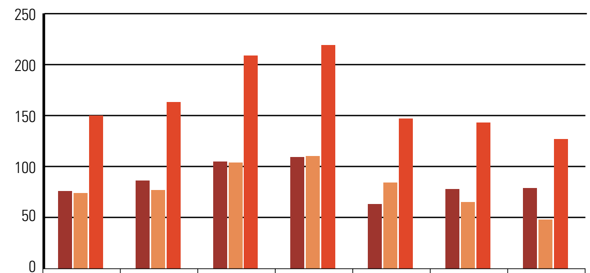
Olkiluoto

The number of maintenance works causing inoperability of components, included in the indicator, decreased in 2007–2009 due to the lower number of fault repairs. In 2010, the number of faults repaired increased while the number of preventive maintenance operations decreased.

In 2015, the number of fault repairs that caused inoperability of components remained at the level of 2011–2014. The number of preventive maintenance tasks slightly increased, improving the ratio of preventive maintenance and fault repairs from 2011. The number of faults repaired at OL2 somewhat increased and the relative number of preventive maintenance tasks also increased more than at OL1, and thus the maintenance ratio increased to 1.7 at OL1 and decreased to 0.65 at OL2. This is close to the values of 2010 and 2011.

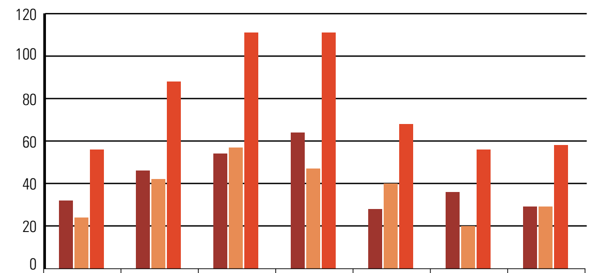
Based on the development of the ratio of preventive maintenance work to fault repairs and an assessment of the work on which the figures are based, the maintenance strategy can be considered successful.

Volume of annual maintenance works of OLC components, Olkiluoto NPP



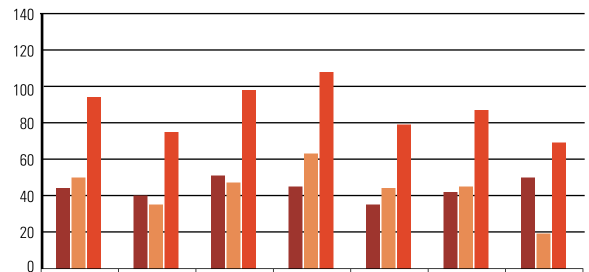
	2009	2010	2011	2012	2013	2014	2015
OL1	76	86	105	109	63	78	79
OL2	74	77	104	110	84	65	48
OL1,2	150	163	209	219	147	143	127

Number of annual failure repair works of OLC components, Olkiluoto NPP



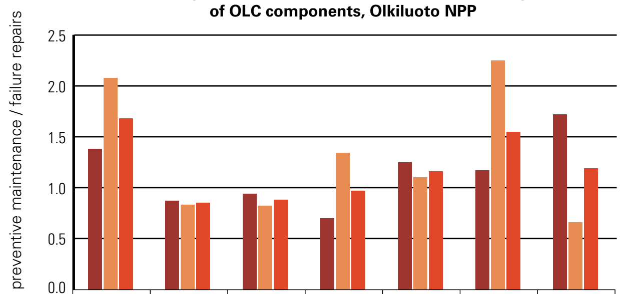
	2009	2010	2011	2012	2013	2014	2015
OL1	32	46	54	64	28	36	29
OL2	24	42	57	47	40	20	29
OL1,2	56	88	111	111	68	56	58

Number of annual preventive maintenance works of OLC components, Olkiluoto NPP



	2009	2010	2011	2012	2013	2014	2015
OL1	44	40	51	45	35	42	50
OL2	50	35	47	63	44	45	19
OL1,2	94	75	98	108	79	87	69

Ratio of preventive maintenance works to failure repairs of OLC components, Olkiluoto NPP



	2009	2010	2011	2012	2013	2014	2015
OL1	1.38	0.87	0.94	0.70	1.25	1.17	1.72
OL2	2.08	0.83	0.82	1.34	1.10	2.25	0.66
OL1,2	1.68	0.85	0.88	0.97	1.16	1.55	1.19

A.I.1c Repair times of components subjectto the OLC

Definition

As an indicator, the average repair time of faults causing the unavailability of components defined in the operational limits and conditions (OLC) is monitored. With each repair, the time recorded is the time of inoperability. In the case of a fault that causes an immediate operation restriction, it is calculated from the detection of the fault to the end of the repair work. If the component is operable until the beginning of repairs, only the time it takes to complete the repairs is taken into account.

Source of data

The data is obtained from the nuclear power plants work order systems as well as maintenance and operation documentation.

Purpose

The indicator shows how quickly failed components subject to the OLC are repaired when compared to the repair time allowed in the OLC. The indicator is used to assess the strategy, resources and effectiveness of NPP maintenance.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

Interpretation of the indicator

Loviisa

The OLC define the maximum allowed repair times for components based on the components' safety significance. The times vary from four hours to 21 days. Furthermore, faults in OLC components are to be repaired within the allotted time without undue delay.

Due to the small amount of work requiring operation restrictions and the varying allowed repair times, an individual operation may have a significant effect on the indicator, even if it is completed within the allotted time. This aspect of the indicator is taken into account in the interpretation of the indicator by evaluating the significance of individual long-term fault repairs in terms of maintenance strategy, resources and efficiency of operations.

The average repair times of faults causing unavailability of components have remained stable at the Loviisa NPP for several years. In 2015, the average repair time for the plant units was 14.5 hours, while the average of the four previous years was 21.8.

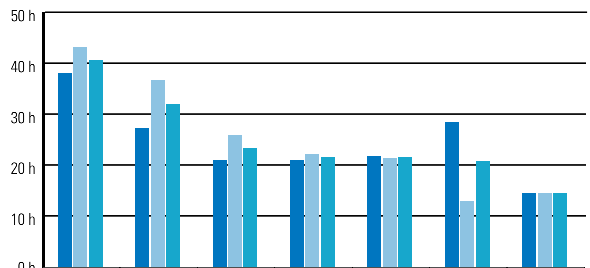
Based on the 2015 indicators and the underlying data, the plant's maintenance operations can be considered appropriate. Despite the positive development in repair times, attention still needs to be paid to the NPP's maintenance on having the necessary resources available for fault repairs, and for carrying out the repairs without unnecessary delays.

Interpretation of the indicator

Olkiluoto

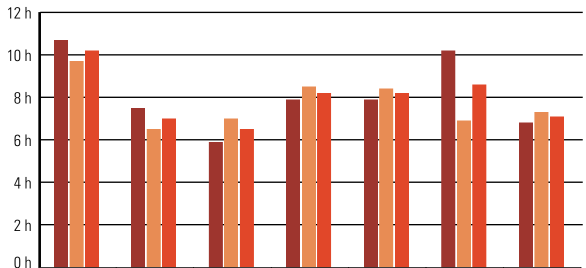
The indicator is used to monitor the repair times of components subject to the operational limits and conditions (OLC). The repair time allowed in the OLC is usually 30 days for faults concerning one train and three days for faults concerning two trains. Depending on the system and the component, other allowed repair times may also be defined in the OLC.

Average of real repair times of OLC component failures, Loviisa NPP



	2009	2010	2011	2012	2013	2014	2015
LO1	38.0	27.3	20.9	20.9	21.7	28.4	14.5
LO2	43.1	36.6	25.9	22.1	21.4	13.0	14.4
LO1,2	40.6	32.0	23.4	21.5	21.6	20.7	14.5

Average of real repair times of OLC component failures, Olkiluoto NPP



	2009	2010	2011	2012	2013	2014	2015
OL1	10.7	7.5	5.9	7.9	7.9	10.2	6.8
OL2	9.7	6.5	7.0	8.5	8.4	6.9	7.3
OL1,2	10.2	7.0	6.5	8.2	8.2	8.6	7.1

In the long term, the average repair time has varied between six to ten hours. In 2015, the average repair time of faults causing inoperability of components subject to the operational limits and conditions (OLC) at OL1 was around 10 h and at OL2 around 7 h. In the case of both plant units, the average repair time of faults causing inoperability of components subject to the OLC was at around the same level as in the previous years, even though the time decreased to the level of 2013 at OL1.

On the basis of the 2015 indicators and the underlying data, the NPP's maintenance operations were appropriate.

A.I.1d Common-cause failure

Definition

As the indicator, the number of common-cause failures of components or systems defined in the operational limits and conditions (OLC) is followed.

Source of data

Data for the indicators is collected from the reports by the power companies of works causing an operation restriction.

Purpose

The indicator is used to follow the quality of maintenance.

Responsible unit/person

Operational safety (KÄY)
Simo Verta (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Loviisa

When a fault is observed in a safety-critical system, component or structure in connection with maintenance, inservice testing or other monitoring operations, the corrective measures include an investigation of whether the fault is a single fault, or whether there might be other similar faults in the system. One potential operational event was identified at the Loviisa power plant in 2015. It involved relays in safety class 2 LARA rectifiers where software common-cause failure could not be completely ruled out.

Olkiluoto

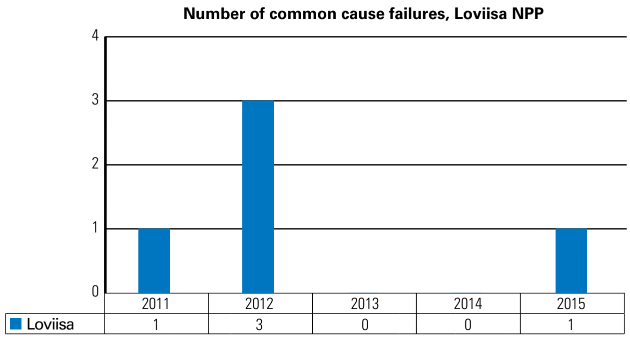
Four common-cause failures were identified at Olkiluoto in 2015. Safety significance of all the identified common-cause failures was low.

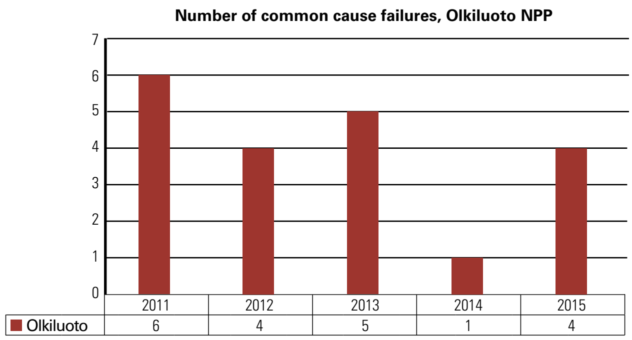
A failure in a shared cooler of a pressurised nitrogen system caused the failure of two compressors. Pressurised nitrogen to achieve the safety function was still available from a backup system, which means that the failure did not have any safety significance.

Two minimum flow valves in the turbine island feedwater system failed because of failures in electric winding. The minimum flow valves are needed when starting up the feedwater pumps. The failure could have compromised the starting of the pumps, but the safety significance is very low because the turbine island feedwater system does not fulfil any safety functions.

Cracks were observed in the hooks of hoists at both plant units. The failures were observed in connection with regular inspections. It was estimated that the cracks had not caused any risk of a load drop.

Cracks were observed in the surface coating of a boom in the hoisting tool for the fuel transport cask at the plant units and in the interim storage facility for spent nuclear fuel. The cracks in the surface coating were detected in connection with a regular inspection. There was a risk of loose components falling into the fuel pool, but the incident did not have any actual safety significance.





A.I.1g Production losses due to faults

Definition

As the indicator, the loss of production caused by faults in relation to rated power (gross) is monitored.

Source of data

Data for the indicator is obtained from the annual and quarterly reports submitted by power companies.

Purpose

The indicator is used to follow the significance of faults from the point of view of NPP production.

Responsible unit/person

Operational safety (KÄY)
Simo Verta (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Production losses due to faults have been small at both Loviisa and Olkiluoto, which is also indicated by the nuclear power plants' high load factors.

Loviisa

The number of faults resulting in production losses typically varies a great deal year by year. A significant failure of a single component may require a cold shutdown of the plant, which inevitably causes major production losses. On the other hand, several minor failures may occur over the course of the year without having any major impact on the annual production volume.

In 2015, Loviisa 1 experienced only a few faults resulting in production losses. The most production losses arose from the separation of an HP heater to repair a leak in October.

Most of the faults resulting in production losses at Loviisa 2 (around half of them) in 2015 resulted from the loss of the holding current of a control rod, which made the rod drop into its lower position in November. The plant was placed into a repair outage to repair the control rod drive mechanism. Around one quarter of the production losses were caused by increased vibration of a reactor coolant pump. The pump had to be shut down because of the vibration.

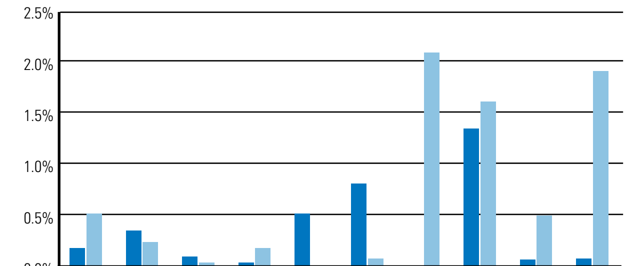
Olkiluoto

The number of faults resulting in production losses typically varies a great deal year by year. A significant failure of a single component may require a cold shutdown of the plant, which inevitably causes major production losses. On the other hand, several minor failures may occur over the course of the year without having any major impact on the annual production volume.

In 2015, Olkiluoto 1 experienced fewer faults resulting in production losses than on average. There were only a few faults resulting in production losses also in the two previous years.

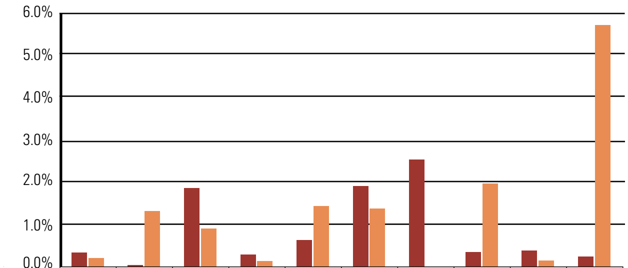
An unplanned maintenance outage of three weeks took place at Olkiluoto 2 in February 2015. It was caused by a water leak in the main generator. This incident is also the underlying reason behind the clearly higher number of faults resulting in production losses than in the previous years. Other faults resulting in production losses at OL2 were minor.

Loss of power production due to failures, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0.17	0.34	0.09	0.03	0.51	0.80	0.00	1.34	0.06	0.07
LO2	0.51	0.23	0.03	0.17	0.00	0.07	2.08	1.60	0.49	1.90

Loss of power production due to failures, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.33	0.04	1.84	0.29	0.63	1.89	2.51	0.35	0.38	0.24
OL2	0.21	1.31	0.90	0.14	1.42	1.37	0.00	1.95	0.15	5.66

A.I.2 Exemptions and deviations from the OLC

Definition

As indicators, the number of non-conformances with the operational limits and conditions (OLC), as well as the number of exemptions granted by STUK, are monitored.

Source of data

Data for the indicators is collected from applications for exemption orders by the power companies and from event reports.

Purpose

The indicator is used to follow the power companies' activities in accordance with the operational limits and conditions: compliance with the OLC and identified situations during which it is necessary to deviate from the OLC; conclusions regarding the appropriateness of the OLC can also be made based on this data.

Responsible unit/person

Operational safety (KÄY)
Simo Verta (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

The main purpose of the OLC exemption procedure is to enable modifications and maintenance that will improve safety and plant availability.

Non-conformance with the OLC refers to a situation where the NPP or a system or component of the NPP is not in a safe state as required by the operational limits and conditions. The objective is to have zero non-conformance events at the NPPs. The licensee must always prepare a special report on each non-conformance and any corrective measures, and submit it to STUK for approval.

Loviisa

Exemptions

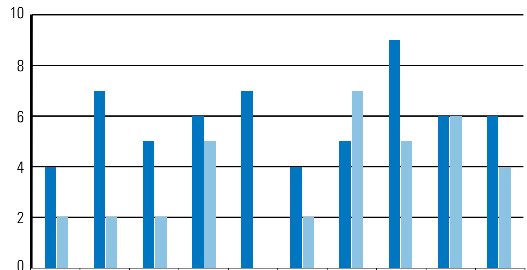
Based on the last ten years (2005–2014), the Loviisa NPP applies for STUK's approval for exemptions from the OLC six times per year on average. The number of applications in 2015 (six applications) was in line with the average. Five of the applications involved modifications and one an inservice inspection of a piece of pressure rated equipment. As the planned deviations had no significant safety implications, STUK approved the applications.

Non-conformance with the OLC

In 2015, four events during which the plant did not comply with the OLC without an advance safety analysis and approval were detected at the Loviisa nuclear power plant. Such events have occurred three times per year on average during the past ten years (2005–2014). All events that were non-compliant with the OLC in 2015 are described in Chapter 4.1.2 of this annual report and Appendix 3.

The Loviisa NPP analyses all non-conformances with the OLC within a month of detection. The analysis includes finding out the underlying causes, assessing the safety significance of the event and determining corrective measures to prevent reoccurrence of the deviations. The results of the analysis are documented in a special report (indicator A.II.1). One key issue is identifying the possibility of reoccurrence, i.e. studying whether a similar event has occurred in the past and whether the corrective measures implemented at the time were sufficient. One issue in common to several (eight) of the events in 2012–2015 was non-compliance with the OLC during the changing of a plant unit's operating mode, i.e. either when switching the unit from load operation to shutdown or from shutdown to load operation. The shutdown or startup of a plant unit is implemented in stages. Before moving on to the next stage, it must be verified that all the requirements for the next stage have been met. These inspections were not fully successful in the case of these events. One must make sure that there are no defects that could lead to an inadvertent deviation in people's knowledge of the OLC, procedures related to compliance with the OLC or the formatting of the OLC themselves.

Number of deviations from the OLC, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Exemptions	4	7	5	6	7	4	5	9	6	6
Deviations	2	2	2	5	0	2	7	5	6	4

Olkiluoto

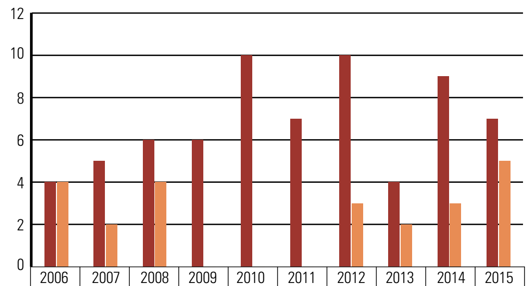
Based on data from the last ten years (2004–2015), the Olkiluoto nuclear power plant applied for STUK's approval for exemptions from the OLC seven times per year on average. Hence, the number of applications in 2015 (seven) was in line with the average. Five of the applications involved modification of a radiation measuring system and two modification of an auxiliary feedwater system recirculation line. STUK approved all the applications, except for one. STUK did not approve TVO's application for a deviation from the OLC to implement a modification in the auxiliary feedwater system recirculation line at OL2. STUK rejected the application because vibration whose cause could not be identified was observed in the piping when the implementation of a similar modification was being tested at OL1. STUK stated that the modification may only be implemented at OL2 if the underlying cause for the vibration at OL1 is detected and corrective measures are determined.

In 2004 and 2005, the number of deviations was increased by work and installations related to the modernisation of OL1 and OL2 and the construction of OL3. Similarly, major modifications were carried out in 2010 and 2011.

Non-conformance with the OLC

In 2015, TVO reported five events during which the NPP was non-compliant with the OLC without an advance safety analysis and STUK's permission. This number of events is higher than the average number of events during the past ten years (3). A non-conformance with the fuel evacuation requirement took place at the interim storage facility for spent nuclear fuel because the refuelling machine was not able to grab some of the unchanneled assemblies in the storage pools. Inservice testing of containment flooding valves with a mobile diesel aggregate power supply at OL1 was unsuccessful. Weekly iodine sampling, which is part of the radioactive release monitoring, was unsuccessful at OL1 for a period of three weeks/sampling periods, because there was no air flow in the sample line. The remote shutdown station at OL2 was inoperable in breach of the OLC. A pipeline of the auxiliary feedwater system was separated without a work permit at OL1. Special reports on all five deviations from the OLC were submitted to STUK. In these reports, TVO analysed the causes of the events and determined corrective measures to prevent their reoccurrence.

Number of deviations from the OLC, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Exemptions	4	5	6	6	10	7	10	4	9	7
Deviations	4	2	4	0	0	0	3	2	3	5

A.I.3 Unavailability of safety systems

Definition

As the indicators, the unavailability of safety systems is monitored separately for each plant unit. The systems monitored at the Olkiluoto nuclear power plant are the containment spray system (322), the auxiliary feedwater system (327) and the emergency diesel generators (651–656). Those followed at the Loviisa nuclear power plant are the high-pressure safety injection system (TJ), emergency feedwater system (RL92/93, RL94/97) and the emergency diesel generators (EY).

Essentially, the ratio of a system's unavailability hours and its required availability hours is used as the indicator. Unavailability hours are the combined unavailability of redundant trains divided by the number of trains.

Annual plant criticality hours are the availability requirement for the 322, 327, TJ and RL systems. For diesel generators, the requirement is continuous, i.e. equal to annual operating hours.

The unavailability hours of a train include the time required for the planned maintenance of components and unavailability due to faults. The latter includes, in addition to the time spent on repairs, the estimated unavailability time prior to fault detection. If a fault is estimated to have occurred in a previous successful test but to have escaped detection, the time between inservice tests is added to the unavailability time. If a fault has occurred between tests but its date of occurrence is unknown, half of the time period lapsed between tests will be added to the unavailability time. If the fault clearly occurred during an operational, maintenance, testing or other event, the time between the event and the defection of the fault is added to the unavailability time.

Source of data

Data for the indicators is collected from the power companies. The licensee's representatives submit the necessary data to the relevant person in charge at STUK.

Purpose

The indicator indicates the unavailability of safety systems. The indicator is used to track the condition of safety systems and any identifiable trends.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

Interpretation of the indicator

Loviisa

TJ system

Analysis of the unavailability figures of the high pressure safety injection systems of the plant units in 2015 and their background information shows that no faults occurred at Loviisa 1 and two faults, the repairs for which caused the system to be unavailable for 13 hours, occurred at Loviisa 2.

The unavailability of the high pressure safety injection systems was low in 2015, i.e. their condition and availability were good.

RL system

In Loviisa 1, the total unavailability time of the emergency feedwater systems was 80 hours, of which a total of two faults were being repaired for a total of 10 hours during load operation. The rest of the unavailability (70 hours) was caused by the periodic maintenance of a diesel generator of the emergency feedwater system RL94 during the annual outage of Loviisa 1, which is done every two years.

At Loviisa 2, the total unavailability time was 221 hours, of which a total of eight hours were used to repair a fault (one fault) during load operation. The rest of the unavailability (213 hours) was caused by the periodic maintenance of a diesel generator of the emergency feedwater system RL97 during the annual outage of Loviisa 2, which is done every two years.

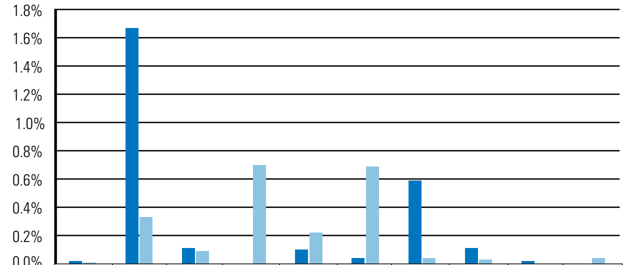
The unavailability of the auxiliary feedwater systems was low in 2015, i.e. their condition and availability were good.

EY system

In 2015, the unavailability time of the eight emergency diesel generators was a total of 343 hours. Maintenance of the diesel generator 22EY03 that is implemented every 17 years accounted for 142 hours of the unavailability.

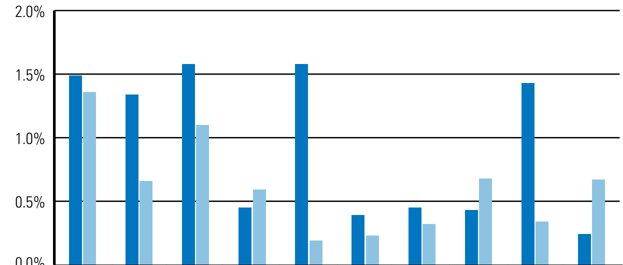
In 2015, there were a total of 13 emergency diesel generator faults causing unavailability.

Unavailability of high pressure safety injection system (TJ), Loviisa NPP



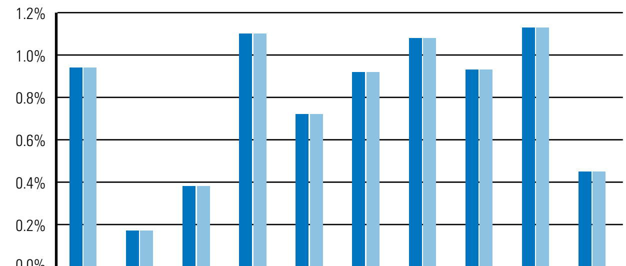
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0.02	1.67	0.11	0.00	0.10	0.04	0.59	0.11	0.02	0.00
LO2	0.01	0.33	0.09	0.70	0.22	0.69	0.04	0.03	0.00	0.04

Unavailability of auxiliary feed water system (RL92/93, RL94/97), Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	1.49	1.34	1.58	0.45	1.58	0.39	0.45	0.43	1.43	0.24
LO2	1.36	0.66	1.10	0.59	0.19	0.23	0.32	0.68	0.34	0.67

Unavailability of emergency diesel generators (EY), Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0.94	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45
LO2	0.94	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45

Of these faults, 6 caused an immediate operation restriction and 7 an operation restriction starting at the beginning of the repair work.

The unavailability rate of the emergency diesel generators in 2015, 0.45%, is still clearly lower than the value for the previous year (2014), which was 1.13%. This is because problems caused by defective control circuit auxiliary relays that were replaced in 2014 had been eliminated.

This means that the unavailability of the diesel generators returned to a low level, i.e. availability was acceptable.

Interpretation of the indicator

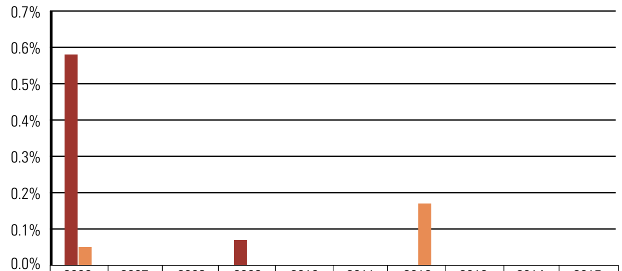
Olkiluoto

The unavailability of the containment spray system in 2007, 2008, 2010, 2011 and 2013 was zero for both plant units, and almost zero in 2009 and 2012.

The unavailability of the auxiliary feedwater system increased significantly from 2014, but the unavailability was practically zero (0.13). The increased unavailability of Olkiluoto 1 in 2006 was due to faults in the recirculation and safety valves in system 327. There were no significant faults in 2007, 2008 or 2009, and the unavailability of the auxiliary feedwater system decreased to nearly zero in 2009 at both plant units. In 2010, unavailability of OL1 was still zero but unavailability of OL2 increased slightly from the previous year, mainly as a result of several new faults discovered during the outage. In 2011, the figure for OL1 was multiplied many times over as the result of a latent fault in one auxiliary feedwater system valve that remained inoperable for 504 hours (cf. Chapter A.II.3). In 2013, the unavailability of the auxiliary feedwater system returned to the level of prior to 2011. This level was retained in 2015 at OL1, and the unavailability of OL2 was almost 0.

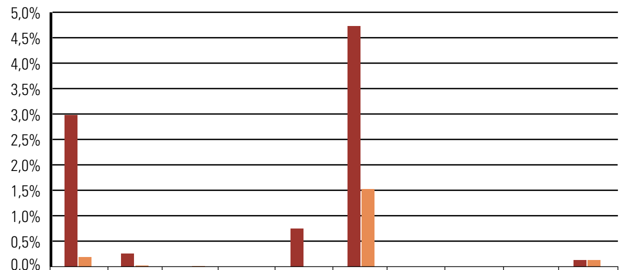
The unavailability of the emergency diesel generators decreased in 2006 and 2007, and was very low as a result. In 2008, the value increased by nearly 95% compared to the previous year. The increase was due to latent faults in the compressed air motors of the diesels in both plant units. In 2009, the unavailability of the diesel generators decreased considerably from the 2008 figures. In 2010, unavailability increased somewhat from the previous year as a result of faults occurring in connection with inservice testing. At OL1, the stator winding of a diesel generator failed in connection with a periodic test in August 2010, and the generator was replaced with an overhauled unit. In 2011, the unavailability of the emergency diesel generators was more than four times higher than in 2010, the highest figure ever recorded while the parameter has been monitored. The reason for the increase was the above-mentioned diesel generator fault, which may have lasted as long as from August 2010 to May 2011. In addition, there were faults in exhaust manifolds and exhaust pipes in 2011. In 2012, the unavailability of the diesel generators was zero. The unavailability of the diesel generators slightly increased in 2014 but still remained very low. The unavailability increased again to 0.96 in 2015.

Unavailability of containment spray system (322), Olkiluoto NPP



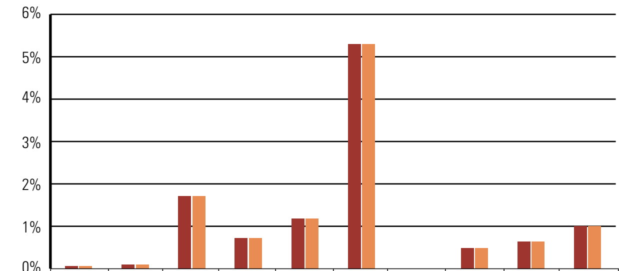
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.58	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
OL2	0.05	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00

Unavailability of auxiliary feed water system (327), Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	2.98	0.25	0.00	0.00	0.74	4.73	0.00	0.00	0.00	0.13
OL2	0.18	0.02	0.01	0.00	0.00	1.52	0.00	0.00	0.00	0.13

Unavailability of emergency diesel generators (651…656), Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.06	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0.64	1.00
OL2	0.06	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0.64	1.00

A.I.4 Radiation exposure

Definition

As the indicators, collective radiation exposure of NPP employees by plant site and plant unit is monitored, together with the annual average of the ten highest occupational doses.

Source of data

The data on the collective occupational dose is received from the quarterly and annual reports of the NPPs as well as the national dose register. The data on individual radiation doses is obtained from the national dose register.

Purpose

The indicators are used to control the radiation exposure of employees. In addition, compliance with the YVL Guide's calculated threshold for one plant unit's collective occupational dose averaged over two successive years is monitored. The threshold value, 2.5 manSv per one gigawatt of net electrical power, means a radiation dose of 1.24 manSv for one Loviisa plant unit and 2.20 manSv for one Olkiluoto plant unit. The collective occupational doses describe the success of the NPP's ALARA programme. The average of the ten highest doses indicates how close to the 20 manSv dose limit the individual occupational doses at the NPPs remain. It also indicates the effectiveness of the NPP's radiation protection unit.

Responsible unit/person

Radiation protection (SÄT)
Tuomas Valmari

Interpretation of the indicator

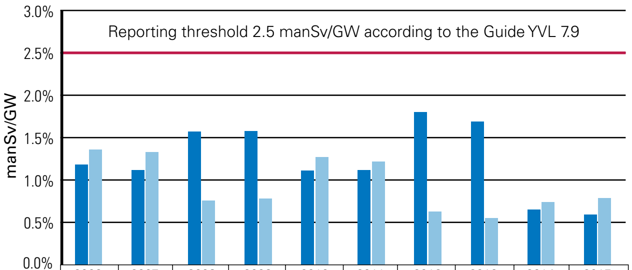
Loviisa

Most doses are incurred through work done during outages. Thus, the duration of the outage and the amount of work having significance on radiation protection affect the annual radiation doses. Both Loviisa plant units have more extensive annual outages every four and eight years (the four-year annual outage and the eight-year annual outage) so that both plant never have a major annual outage during the same year. Four-year and eight-year outages have been held in even years and normal annual outages in odd years. In 2015, there was a short annual outage at both plant units. The effect of annual outages on collective occupational doses can be seen in the *Collective occupational dose, Loviisa* graph. Due to improvements in radiation safety, the radiation doses of employees have decreased, and the collective occupational dose in 2015 was the lowest ever recorded.

The radiation doses for employees of Loviisa nuclear power plant remained below the individual dose limits. In 2015, the average of the ten largest doses was clearly lower than the average for the previous years. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any one year.

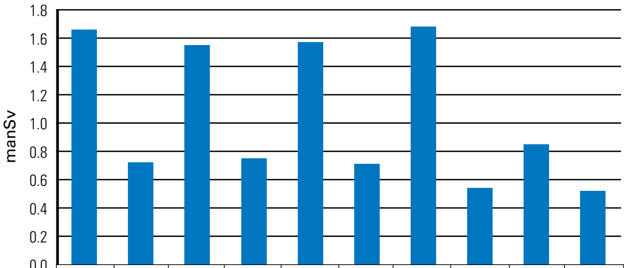
The threshold set for the collective occupational dose was not exceeded in 2015 either. If, at one plant unit, the collective occupational radiation dose averaged over two successive years exceeds 2.5 manSv per one GW of net electrical power, the power company is to report to STUK the causes of this and any measures required to improve radiation safety (Guide YVL 7.9).

Collective dose per 1 GW of net electrical capacity averaged over two succesive years, Loviisa NPP



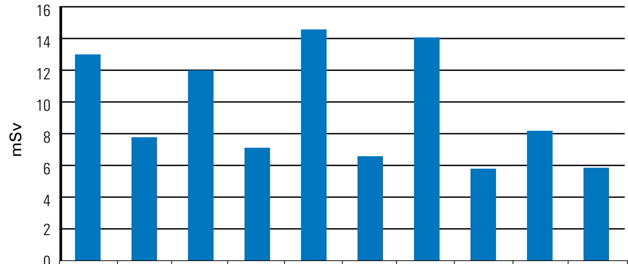
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	1.18	1.12	1.57	1.58	1.11	1.12	1.8	1.69	0.65	0.59
LO2	1.36	1.33	0.76	0.78	1.27	1.22	0.63	0.55	0.74	0.79

Collective occupational radiation dose (manSv), Loviisa NPP



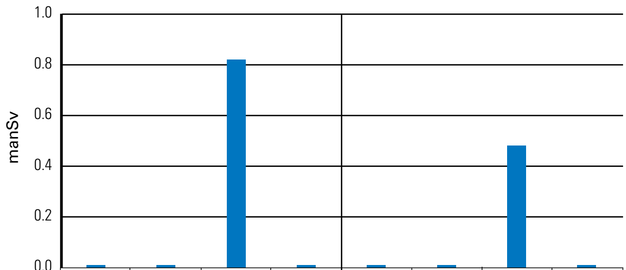
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO	1.66	0.72	1.55	0.75	1.57	0.71	1.68	0.54	0.85	0.52

Average of the ten highest doses (mSv), Loviisa NPP



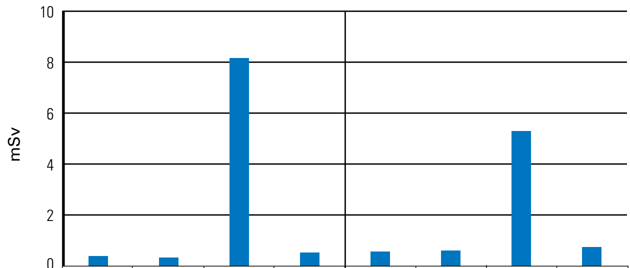
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO	13.00	7.76	11.99	7.11	14.55	6.56	14.06	5.78	8.16	5.86

Collective occupational radiation dose (manSv) quarterly, Loviisa NPP



	I/14	II/14	III/14	IV/14	I/15	II/15	III/15	IV/15
LO	0.01	0.01	0.82	0.01	0.01	0.01	0.48	0.01

Average of the ten highest doses (mSv) quarterly, Loviisa NPP



	I/14	II/14	III/14	IV/14	I/15	II/15	III/15	IV/15
LO	0.39	0.32	8.16	0.52	0.56	0.59	5.29	0.73

Interpretation of the indicator

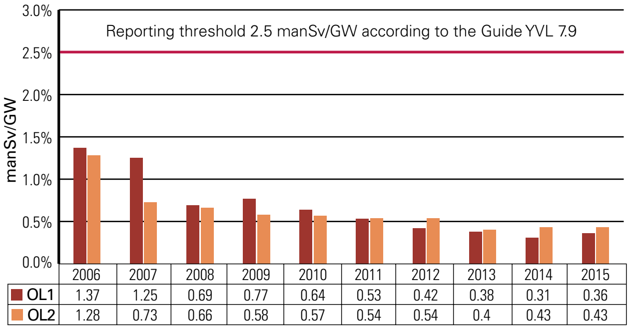
Olkiluoto

Most doses are incurred through work done during outages. Thus, the duration of the outage and the amount of work having significance on radiation protection affect the annual radiation doses. The annual outages of Olkiluoto plant units are divided into two groups: refuelling outages and maintenance outages. The refuelling outage is shorter in duration (approximately 7 days). Length of the maintenance outage depends on the amount of work to be done (2–3 weeks). Annual outages are scheduled so that in the same year, one plant unit undergoes a maintenance outage and the other a refuelling outage. Olkiluoto 1 was subject to a refuelling outage and Olkiluoto 2 to a maintenance outage in 2015.

The radiation doses have clearly decreased after the installation of new moisture separators at the plant units in 2005–2007. The radiation level in the turbine buildings has continued to decrease after the installation of the moisture separators, and this has also decreased the collective occupational dose. Furthermore, improvements aiming at reducing the employees' radiation doses have also been made in radiation protection of the NPP. The collective occupational dose of the employees of Olkiluoto NPP was higher in 2015 than in 2012–2014, but lower than the prevailing level before 2012. In 2015, the average of the ten largest doses was the second lowest ever recorded during the operation of the plant.

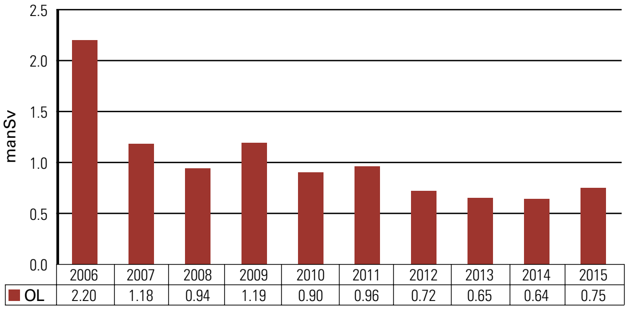
The dose limits set in the Radiation Decree (1512/1991) were not exceeded. The threshold set for the collective occupational dose was not exceeded in 2015 either.

Collective dose per 1 GW of net electrical capacity averaged over two succesive years, Olkiluoto NPP



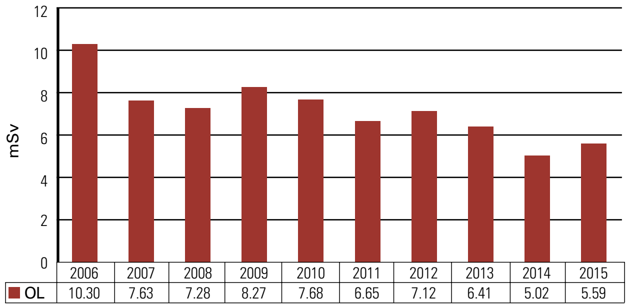
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	1.37	1.25	0.69	0.77	0.64	0.53	0.42	0.38	0.31	0.36
OL2	1.28	0.73	0.66	0.58	0.57	0.54	0.54	0.4	0.43	0.43

Collective occupational radiation dose (manSv), Olkiluoto NPP



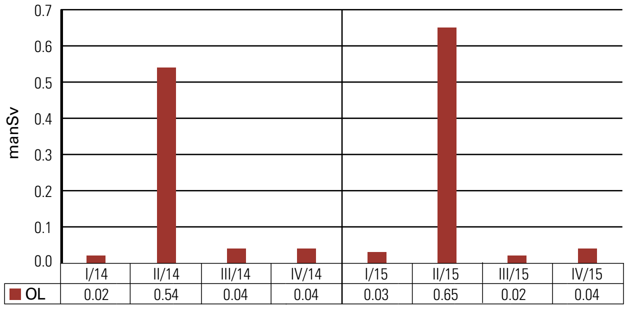
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL	2.20	1.18	0.94	1.19	0.90	0.96	0.72	0.65	0.64	0.75

Average of the ten highest doses (mSv), Olkiluoto NPP



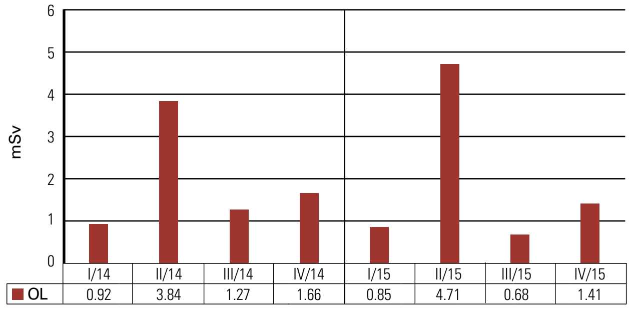
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL	10.30	7.63	7.28	8.27	7.68	6.65	7.12	6.41	5.02	5.59

Collective occupational radiation dose (manSv) quarterly, Olkiluoto NPP



	I/14	II/14	III/14	IV/14	I/15	II/15	III/15	IV/15
OL	0.02	0.54	0.04	0.04	0.03	0.65	0.02	0.04

Average of the ten highest doses (mSv) quarterly, Olkiluoto NPP



	I/14	II/14	III/14	IV/14	I/15	II/15	III/15	IV/15
OL	0.92	3.84	1.27	1.66	0.85	4.71	0.68	1.41

A.I.5 Releases

Definition
As the indicators, radioactive releases into the sea and the air from the NPPs are monitored, together with the calculated dose due to releases to the most exposed individual in the vicinity of the NPP.

Source of data
Data for the indicators is collected from the power companies' quarterly and annual reports. From this data, the calculated radiation dose for the most exposed individual in the vicinity of the NPP is defined.

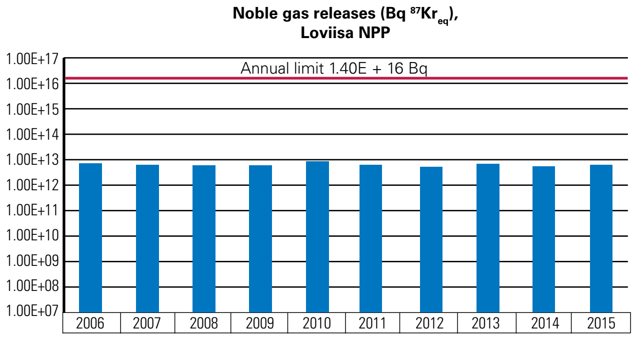
Purpose
The indicator is used to monitor the amount and trend of radioactive releases and assess factors having a bearing on any changes in them.

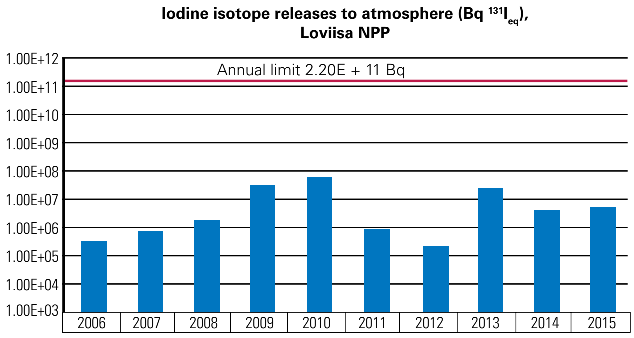
Responsible unit/person
Radiation protection (SÄT), Tuomas Valmari

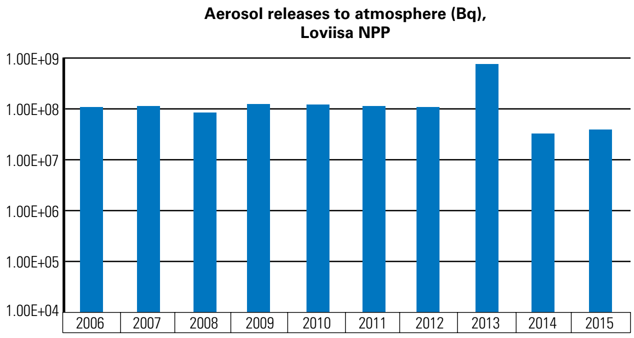
A.I.5a Releases into the air

Interpretation of the indicator
In 2015, radioactive releases into the air from the Loviisa and Olkiluoto nuclear power plants were of the same magnitude as in previous years. The releases clearly remained below the limits set. The most major change in Loviisa over the past few years is a marked decrease in the releases of particulate radioactive aerosols in 2014 and 2015. Radioactive noble gas releases from the Olkiluoto NPP remained below the detection limit in 2014 and 2015.

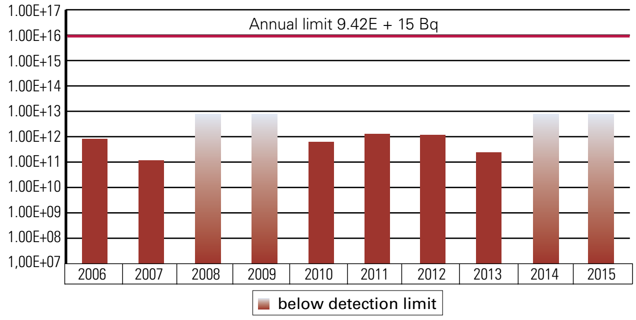
Gaseous fission products, noble gases and iodine isotopes originate from leaking fuel rods, from the minute amounts of uranium left on the outer surfaces of fuel cladding during fuel fabrication and from reactor surface contamination from earlier fuel leaks. At both Loviisa and Olkiluoto, there have been very few leaking fuel rods and the leaks have been small. Aerosol nuclides (including activated corrosion products) are released during maintenance work.







Noble gas releases (Bq $^{87}Kr_{eq}$),
Olkiluoto NPP

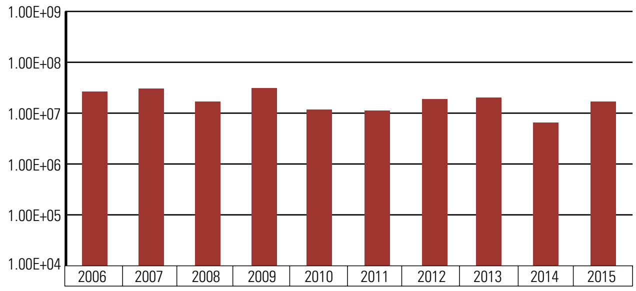


A.I.5b Releases into the sea

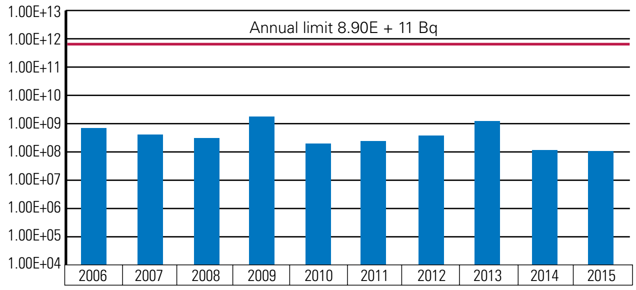
Interpretation of the indicator

Releases of radioactive substances emitting gamma radiation into the environment from the Loviisa and Olkiluoto nuclear power plants remained clearly below the set limits. In 2009 and 2013, the Loviisa NPP released low-activity evaporator bottom into the sea as planned. Consequently, the releases of substances with gamma activity were larger than the average in those years. Releases of substances with gamma activity into the sea from both nuclear power plants have decreased in recent years.

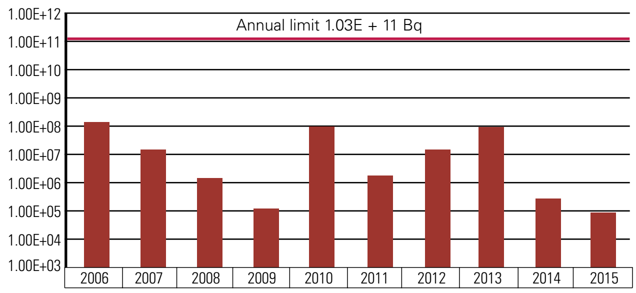
Aerosol releases to atmosphere (Bq),
Olkiluoto NPP



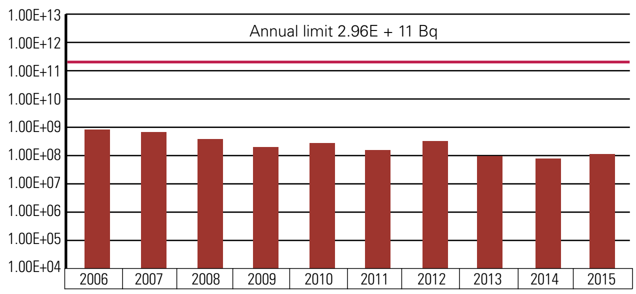
Gamma activity of liquid effluents (Bq),
Loviisa NPP



Iodine isotope releases to atmosphere (Bq $^{131}I_{eq}$),
Olkiluoto NPP



Gamma activity of liquid effluents (Bq),
Olkiluoto NPP

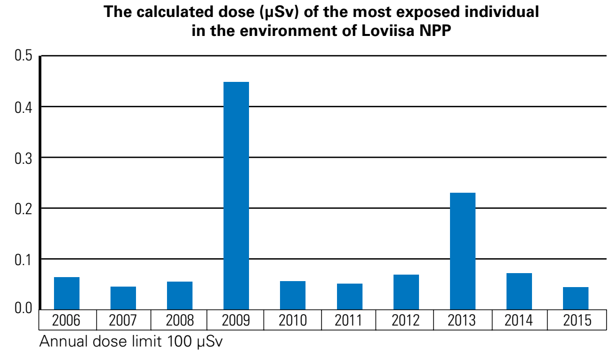


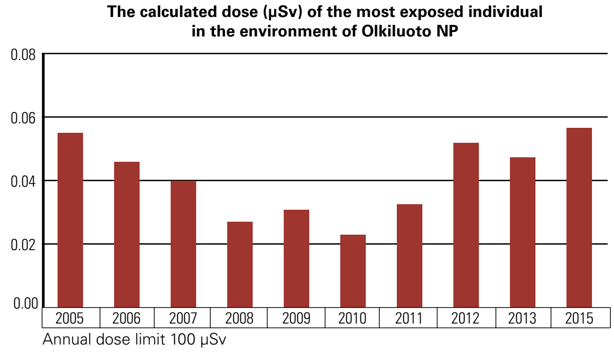
A.I.5c Population exposure

Interpretation of the indicator

Assessment of the radiation dose of the most exposed individual in the vicinity of a nuclear power plant is based on information about the NPP's releases and meteorological measurements. The exposure routes that are taken into account include external radiation and internal radiation, i.e. radiation caused by radioactive materials ending up inside the body via air or food.

In 2015, the radiation doses of the most exposed individual in the vicinity of the Loviisa and Olkiluoto nuclear power plant were normal. Larger radiation doses in 2004 and 2009 in Loviisa were caused by the discharge of evaporator bottom into the sea. The radiation doses of both NPPs were less than 0.1% of the limit of 100 microsieverts that is established in the Government Decree (733/2008).





A.I.6 Investments in facilities

Definition

Investments in nuclear power plant maintenance and modifications in the current value of money adjusted by the building cost index.

Source of data

The licensee submits the necessary data directly to the person responsible for the indicator.

The indicator demonstrates the relative fluctuation of investments. The amounts given in euros are confidential information of the power companies involved, and not to be published here. Furthermore, the scales of the investment and modernisation graphs for Loviisa and Olkiluoto nuclear power plants are not mutually comparable.

Purpose

The indicator is used to follow the amount of investments in plant maintenance and their fluctuations.

Responsible unit/person

Operational safety (KÄY)
Simo Verta (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

The variation of the indicator clearly shows the investments related to the power upgrades and modernisation projects of the nuclear power plants. Both NPPs have paid great attention to lifecycle management, which also shows as continuous long-term investment plans. The renewal of the operating licence of the Loviisa NPP in 2007 and the intermediate assessment carried out at Olkiluoto in 2008 have also had an impact on the investment plans.

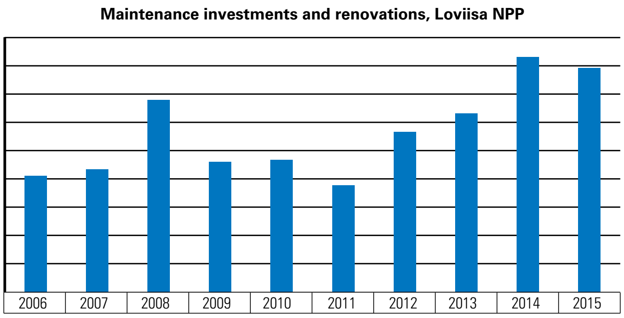
Loviisa

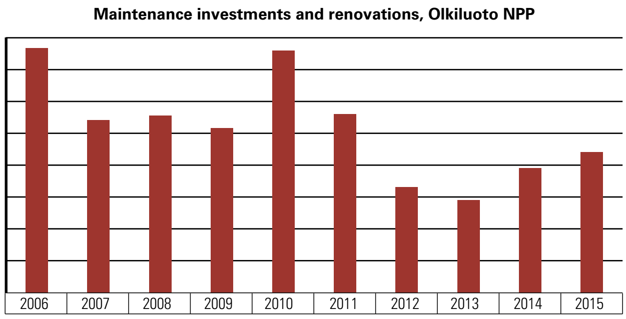
Many modification projects and other projects span over the course of several years, which means that their total costs are also divided between several years. For example, investments in the Loviisa I&C renewal started in 2007. Other major investments in 2015 included modernisation of the reactor coolant system pressure control system, a reheater upgrade, a turbine modernisation project, an upgrade of a maintenance data system and modernisation of the service water system piping.

Olkiluoto

Investments in 2015 are close to the nuclear power plant's average value for 1981–2015. Slightly more investments than during the three previous years were made in 2015, but the investment level is still clearly below the top level of 2010 and 2011 when LP steam turbine of both units were replaced, for example.

Most major investments in 2015 included replacement of low voltage switchgear and auxiliary transformers, construction of a remote shutdown station and replacement of the emergency diesel generators. Replacement of the reactor coolant pumps and their frequency converters started in 2015.





A.II Operational events

A.II.1 Number of events

Definition

As the indicators, the number of operational event reports is monitored in compliance with Guide YVL A.10. The new Guide YVL A.10 entered into force in late 2015, which is why the old terms in compliance with YVL 1.5 are still used in the indicators. In addition to special reports and transient reports, the new operational event reports include other plant events submitted to STUK for information. A special report corresponds to an operational event report submitted for approval in the new Guide YVL A.10.

Source of data

Data for the indicators is obtained from the STUK document management system (SAHA).

Purpose

The indicator is used to follow the number of safety-significant events.

Responsible unit/person

Operational safety (KÄY)
Simo Verta (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Loviisa

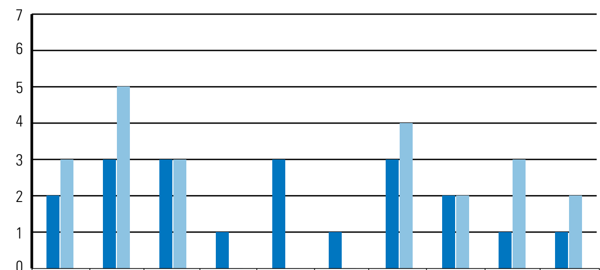
No reactor trips occurred at the Loviisa nuclear power plant in 2015.

Based on data from the previous ten years (2005–2014), the average number of annual events warranting a special report is three to four per year, while the average number of events warranting a transient report is five per year. The number of events warranting a special report was normal in 2015 (five in total) and the number of events warranting a transient report (three in total) was below the average. Many of the events warranting a special report are deviations from the operational limits and conditions (OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

Events warranting a special report in 2015 are described in Appendix 3.

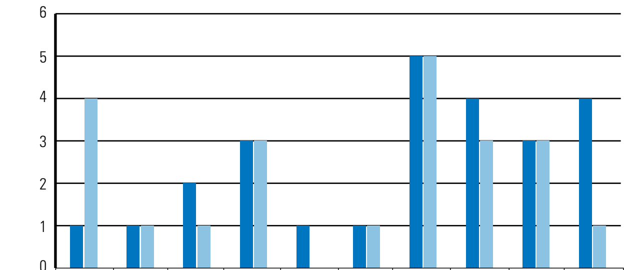
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events by plant unit since, for technical reasons, the reports that concern both plant units have been entered for Loviisa 1 alone. In 2015, one event warranting a special report concerned both plant units.

Number of operational transient reports, Loviisa NPP



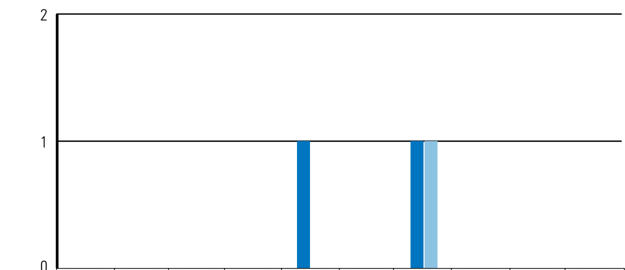
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	2	3	3	1	3	1	3	2	1	1
LO2	3	5	3	0	0	0	4	2	3	2

Number of Special Reports, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	1	1	2	3	1	1	5	4	3	4
LO2	4	1	1	3	0	1	5	3	3	1

Number of reactor scrams, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0	0	0	0	1	0	1	0	0	0
LO2	0	0	0	0	0	0	1	0	0	0

Olkiluoto

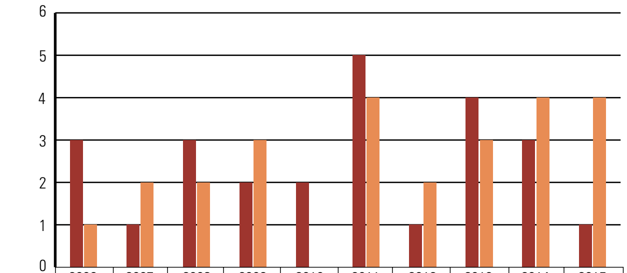
No reactor trips occurred at the Olkiluoto nuclear power plant in 2015. Based on the data from the last ten years, an average of zero to one reactor trips per year occurs at the Olkiluoto NPP. During the previous decade (1993–2001), an average of almost three to four reactor trips occurred each year. The larger number of trips is explained by the fact that it also includes reactor trips during annual outages that occurred, for example, in connection with testing of the reactor protection system.

Based on data from the previous ten years (2005–2014), the average number of annual events warranting a special report is three to four per year, while the average number of events warranting a transient report is five per year. The number of events warranting a special report slightly higher than the average in 2015 (five in total) and the number of events warranting a transient report (five in total) was close to the annual average. Many of the events warranting a special report are deviations from the operational limits and conditions (OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

Events warranting a special report in 2015 are described in Appendix 3.

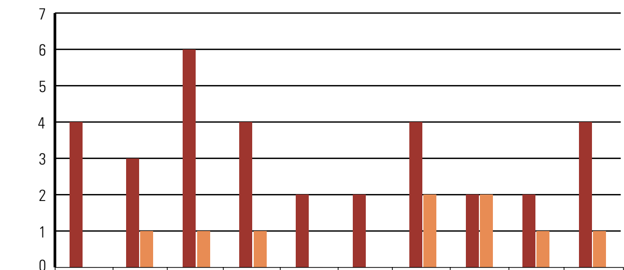
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events by plant unit since, for technical reasons, reports that concern both plant units or the interim storage facility for spent nuclear fuel have been entered for Olkiluoto 1 alone. One special report in 2015 concerned the interim storage facility for spent nuclear fuel.

Number of operational transient reports, Olkiluoto NPP



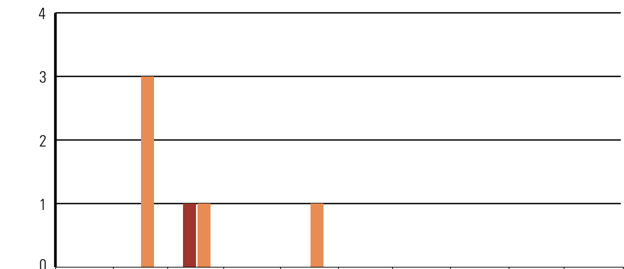
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	3	1	3	2	2	5	1	4	3	1
OL2	1	2	2	3	0	4	2	3	4	4

Number of Special Reports, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	4	3	6	4	2	2	4	2	2	4
OL2	0	1	1	1	0	0	2	2	1	1

Number of reactor scrams, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0	0	1	0	0	0	0	0	0	0
OL2	0	3	1	0	1	0	0	0	0	0

A.II.3 Risk-significance of events

Definition

As the indicator, the risk-significance of events caused by component unavailability is monitored. An increase in the conditional core damage probability (CCDP) associated with each event is used as the measure of a risk. CCDP takes the duration of each event into consideration. Events are divided into three categories: 1) unavailability due to component faults, 2) planned unavailability and 3) initiating events. Furthermore, events are grouped into three categories according to their risk-significance (CCDP): the most risk-significant events (CCDP>1E–7), other significant events (1E-8 ≤ CCDP < 1E–7) and other events (CCDP < 1E–8). The indicator is the number of events in each category.

Unavailability caused by work for which STUK has granted an exemption is included in category 2. Any non-conformances with the OLC that can be applied to this indicator are included in category 1. Non-compliances with the OLC are also dealt with in Chapter A.I.2.

Calculations concerning the Olkiluoto nuclear power plant have been made with FinPSA software and those concerning Loviisa nuclear power plant with RiskSpectrum software. For the Loviisa NPP, calculations of a simultaneous fault in several components are based solely on the load operation model, which means that the results are not as exact as for single faults which have been calculated for all operating modes. The modelling of simultaneous faults across all operating modes (17 of them) would be possible, but the calculation time would be too long when compared to the benefits gained. This year, no simultaneous faults of several components with the highest risk-significance occurred.

Source of data

Data for the calculation of the indicators is collected from the power companies' reports and applications for exemptions.

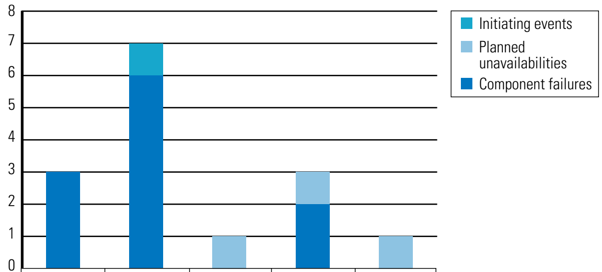
Purpose

The indicator is used to follow the risk-significance of component unavailability and to assess risk-significant initiating events and planned unavailability. Special attention is paid to recurring events, common cause faults, simultaneously occurring faults and human errors. Another objective of the event analysis is to systematically search for any signs of a deteriorating organisational and safety culture.

Responsible unit/person

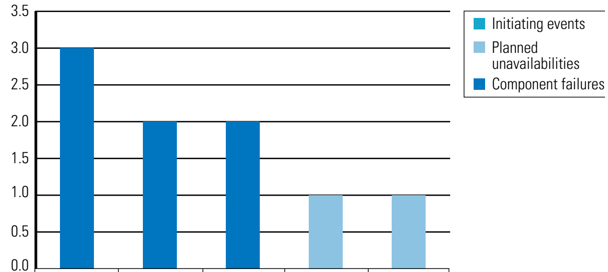
Risk assessment (RIS), Jorma Rantakivi (PRA computation)
Operational safety (KÄY) (fault data)

Most risk-significant events
CCDP ≥ 1E-7
Loviisa 1 (total number of events)



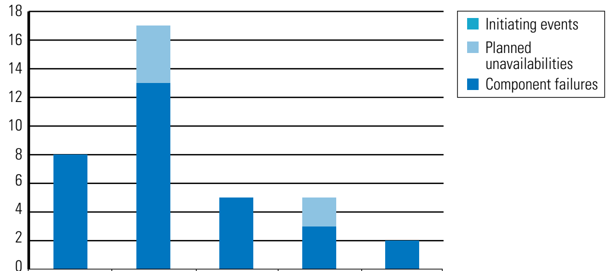
	2011	2012	2013	2014	2015
Initiating events	0	1	0	0	0
Planned unavailabilities	0	0	1	1	1
Component failures	3	6	0	2	0

Most risk-significant events
CCDP ≥ 1E-7
Loviisa 2 (total number of events)



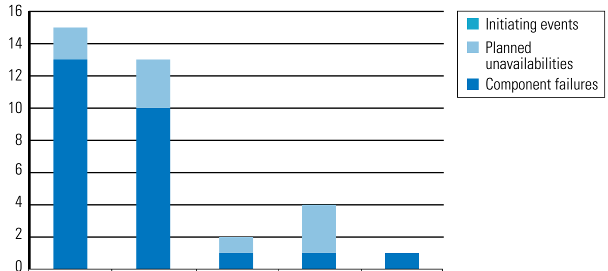
	2011	2012	2013	2014	2015
Initiating events	0	0	0	0	0
Planned unavailabilities	0	0	0	1	1
Component failures	3	2	2	0	0

Other significant events
1E-8 ≤ CCDP < 1E-7
Loviisa 1 (total number of events)



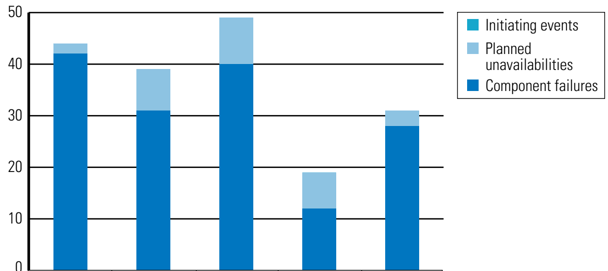
	2011	2012	2013	2014	2015
Initiating events	0	0	0	0	0
Planned unavailabilities	0	4	0	2	0
Component failures	8	13	5	3	2

Other significant events
1E-8 ≤ CCDP < 1E-7
Loviisa 2 (total number of events)



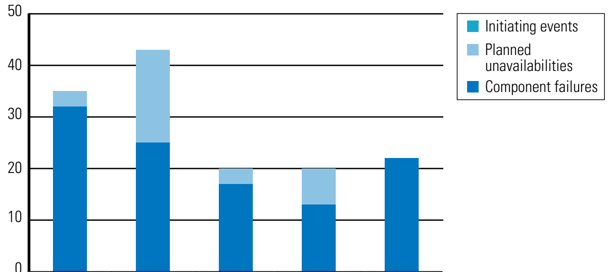
	2011	2012	2013	2014	2015
Initiating events	0	0	0	0	0
Planned unavailabilities	2	3	1	3	0
Component failures	13	10	1	1	1

Other events CCDP < 1E-8
Loviisa 1 (total number of events)



	2011	2012	2013	2014	2015
Initiating events	0	0	0	0	0
Planned unavailabilities	2	8	9	7	3
Component failures	42	31	40	12	28

Other events CCDP < 1E-8
Loviisa 2 (total number of events)



	2011	2012	2013	2014	2015
Initiating events	0	0	0	0	0
Planned unavailabilities	3	18	3	7	0
Component failures	32	25	17	13	22

Interpretation of the indicator

Loviisa

A brief description of the most significant events regarding risks is provided below.

Loviisa 1:

1. The maintenance of the startup and shutdown pump system of LO2 took 199 hours during the annual outage of LO2. This caused a risk for LO1 that was in power operation because the startup and shutdown pump system of LO2 can also be used to cool LO1. The calculated CCDP was 3.3E-7.

Loviisa 2:

1. The maintenance of the startup and shutdown pump system of LO1 took 68 hours during the annual outage of LO1. This caused a risk for LO2 that was in power operation because the startup and shutdown pump system of LO1 can also be used to cool LO2. The calculated CCDP was 1.1E-7.

Olkiluoto

A brief description of the significant events is given below.

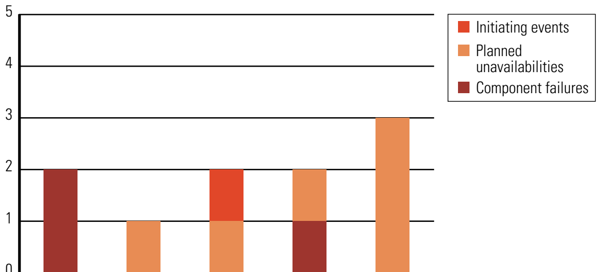
Olkiluoto 1:

1. Venting and filling nozzles were installed in a new recirculation line of the emergency feedwater system train 327 D. The unavailability time was 56.1 h. CCDP: 1.1E-07.
2. Preventive maintenance of a diesel generator in the B train took 110 h. CCDP: 1.0E-07.
3. Preventive maintenance of a diesel generator in the D train took 112 h. CCDP: 1.1E-07.

Olkiluoto 2:

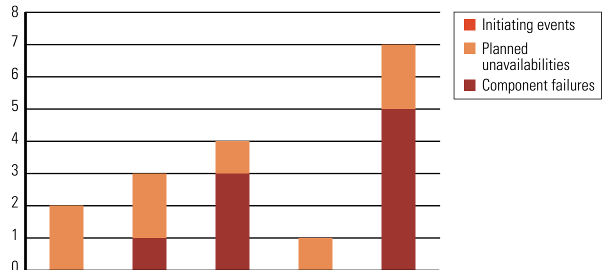
1. The flow measured during inservice testing of the emergency feedwater system train 327 A was too low. A hidden fault. The unavailability time was 1,009 h. CCDP: 9.0E-07
2. A diesel generator switch did not close during the inservice testing of a diesel generator in train B. A hidden fault. The unavailability time was 330 h. When the diesel generator was unavailable, train 712 A of the service water system was unavailable due to planned maintenance (replacement of a flow measurement) for 30 hours. Combined CCDP of these events was 4.8E-7.

Most risk-significant events
CCDP ≥ 1E-7
Olkiluoto 1 (total number of events)



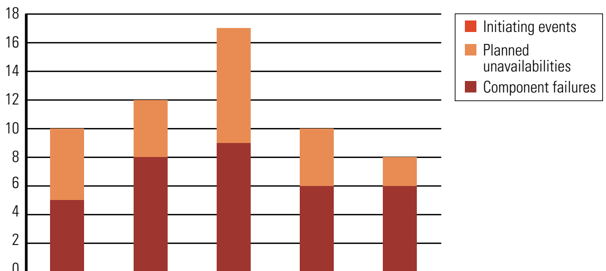
	2011	2012	2013	2014	2015
	0	0	1	0	0
	0	1	1	1	3
	2	0	0	1	0

Most risk-significant events
CCDP ≥ 1E-7
Olkiluoto 2 (total number of events)



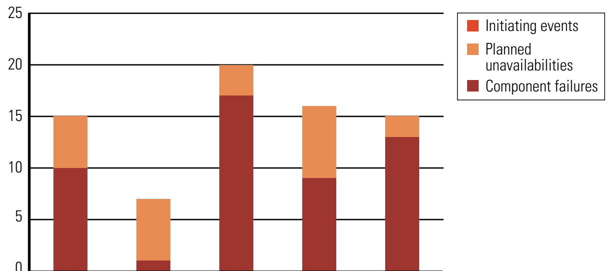
	2011	2012	2013	2014	2015
	0	0	0	0	0
	2	2	1	1	2
	0	1	3	0	5

Other significant events
1E-8 ≤ CCDP < 1E-7
Olkiluoto 1 (total number of events)



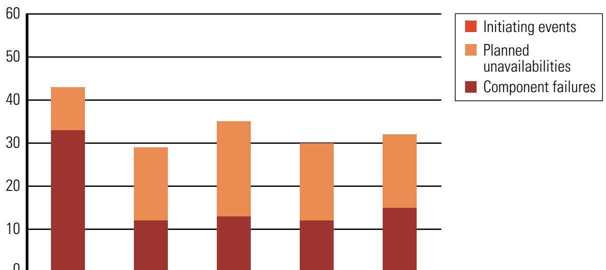
	2011	2012	2013	2014	2015
	0	0	0	0	0
	5	4	8	4	2
	5	8	9	6	6

Other significant events
1E-8 ≤ CCDP < 1E-7
Olkiluoto 2 (total number of events)



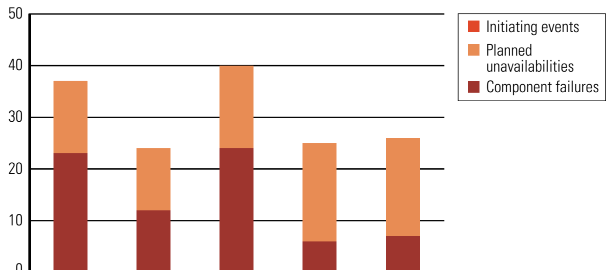
	2011	2012	2013	2014	2015
	0	0	0	0	0
	5	6	3	7	2
	10	1	17	9	13

Other events CCDP < 1E-8
Olkiluoto 1 (total number of events)



	2011	2012	2013	2014	2015
	0	0	0	0	0
	10	17	22	18	17
	33	12	13	12	15

Other events CCDP < 1E-8
Olkiluoto 2 (total number of events)



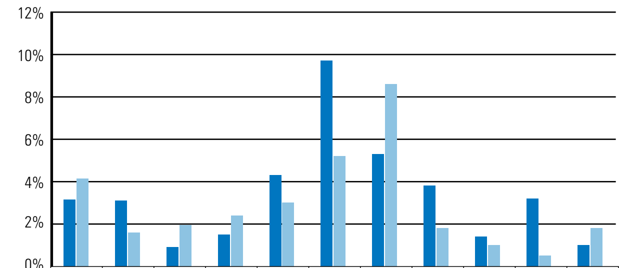
	2011	2012	2013	2014	2015
	0	0	0	0	0
	14	12	16	19	19
	23	12	24	6	7

3. Preventive maintenance of a diesel generator in the B train took 109 h. CCDP: 1.0E-07.
4. Preventive maintenance of a diesel generator in the D train took 102 h. CCDP: 1.0E-07.
5. Isolation valve V214 in the minimum circulation line of train B of the core spray system 323 was triggered by torque. The minimum circulation line is used when starting up and shutting down the system. A hidden fault. The unavailability time was 386 h. CCDP: 2.1E-7.
6. A switchgear fault occurred in train C of the emergency feedwater system 327 during start-up. A hidden fault. The unavailability time was 256 h. CCDP: 3.9E-7.
7. Flow measurement of a pump in train B of the core spray system was unavailable. The I&C requires the flow measurement when starting up and shutting down the pump. A hidden fault. CCDP: 4.1E-7.

The combined total CCDP of all three categories divided by the probability of a severe accident gives an overview of the risk-significance of operational events. To facilitate analysis, risk calculation is based on conservative assumptions and simplifications, which materially weakens the applicability of the results for trend monitoring. If the risk-significance remains at the same average level year after year, the annual fluctuation does not warrant particular attention.

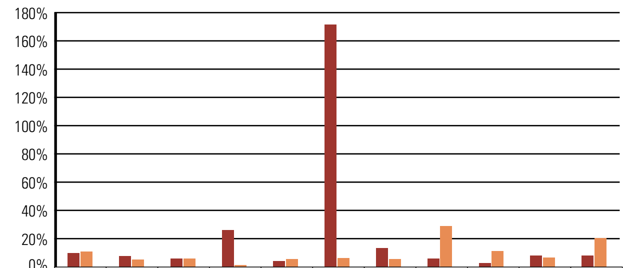
At Loviisa 1, Loviisa 2 and Olkiluoto 1, the risk caused by operational activities remained at around the same level as in the past years in 2015. Four hidden faults in emergency core cooling systems and one hidden fault in an emergency diesel generator at Olkiluoto 2 increased the additional risk from operational activities to a fairly high level (20.5%).

Risk contribution of the safety system unavailability at Loviisa NPP
Persentage of the average annual core damage risk



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	3.15	3.10	0.90	1.50	4.30	9.70	5.30	3.80	1.40	3.20	1.00
LO2	4.14	1.60	1.95	2.40	3.00	5.20	8.60	1.80	1.00	0.50	1.80

Risk contribution of the safety system unavailability at Olkiluoto NPP
Persentage of the average annual core damage risk



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	9.64	7.60	6.00	26.10	4.00	171.40	13.10	5.90	2.80	7.90	8.00
OL2	10.95	5.00	6.00	1.30	5.40	6.30	5.40	29.00	11.00	6.40	20.50

A.II.4 Accident risk at nuclear facilities

Definition

As the indicator, the annual probability of an accident leading to severe damage to nuclear fuel (core damage frequency) is monitored. The accident risk is presented per plant unit.

Source of data

The data is obtained as the result of probabilistic risk assessments (PRA) of the nuclear power plants. The PRA is based on detailed calculation models, which are continuously developed and complemented. A total of 200 man-years have been used at Finnish NPPs to develop the models. The basic PRA data includes globally collected reliability information of components and operator activities, as well as operating experience from Finnish NPPs.

Purpose

The indicator is used to follow the development of the nuclear power plant's accident risk. The objective is to operate and maintain the NPP in such a manner that the accident risk decreases or remains stable. Probabilistic risk assessments can assist in detecting a need to make modifications to the NPP or revise operating methods.

Responsible unit/person

Risk assessment (RIS), Jorma Rantakivi
(PRA computation)
Operational safety (KÄY) (fault data)

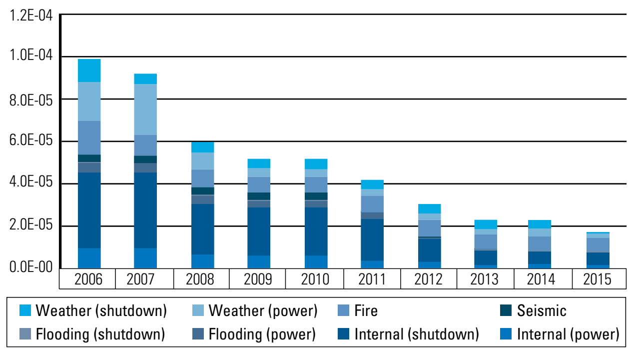
Interpretation of the indicator

When assessing the indicator, one must keep in mind that it is affected by both the development of the NPP and the development of the calculation model. Plant modifications and changes in methods, carried out to remove risk factors, will decrease the indicator value. An increase in the indicator value may be due to the model being extended to new event groups, or the identification of new risk factors. Furthermore, developing more detailed models or obtaining more detailed basic data may change the risk estimates in either direction. For example, an increase in the Loviisa indicator in 2003 was due to the PRA being extended to cover exceptionally harsh weather conditions and oil accidents at sea during a refuelling outage. In the following year, the indicator value decreased, partly as a result of a more detailed analysis of these factors.

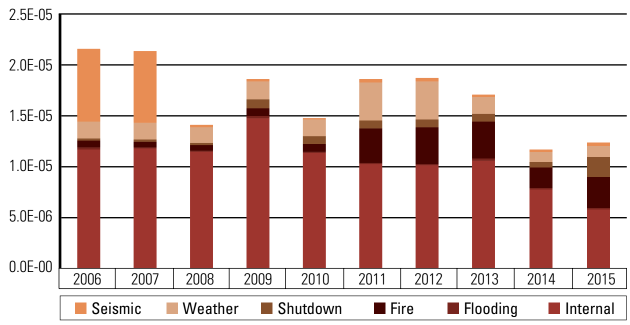
Loviisa NPP's accident risk has continued to decrease over the last ten years, and new risk factors, discovered as the scope of the PRA has been extended, have been efficiently eliminated. The indicator decreased in 2007 due to the new service water line completed during the period. The new line allows for the alternative intake of seawater from the outlet channel to cool the NPP when it is at a shutdown. The change decreases the risks in situations where algae, frazil ice or an oil spill endangers the availability of seawater via the conventional route. The decrease of the indicator in 2008 and in the following years result from more detailed assessments performed in conjunction with the renewal of the operating licence, as well as changes at the NPP planned to be carried out earlier or in connection with the licence renewal. Such changes include decreasing the probability of a criticality accident using, for example, boron analysers, and decreasing the probability of an external leak.

At the end of 2015, the core damage frequency or annual probability of core damage calculated

Fluctuation of the calculated annual core damage frequency for Loviisa plant units during 2006–2015



Fluctuation of the calculated annual core damage frequency for Olkiluoto plant units during 2006–2015



with the PRA model of Loviisa 1 was around 1.7 × 10^{-5}/year, which is around 26% lower than in 2014 (2.3 × 10^{-5} /year). The core damage frequency of Loviisa 2 was 2.0 × 10^{-5}/year, which is 20% less than in 2014 (2.5 × 10^{-5}/year). The difference between the plant units' risk assessments is due to differences in ventilation and air conditioning systems that contain safety systems, for example. The risk has decreased from the previous year mainly because of new cooling towers that were commissioned in 2015. They allow for the removal of residual heat in the long term also if the service water systems are blocked due to a major oil leak at sea, for example.

The indicator for the Olkiluoto NPP decreased by approximately 30% in 2008 compared to previous years' relatively stable values. The decrease was mainly due to the more detailed modelling of earthquake events and changes carried out at the NPP to improve seismic qualification. The increase in 2009 was due to the fact that a heat exchanger in the screening system could not be used for residual heat removal after all, contrary to earlier assessments. The decrease of the risk in 2010 was due to changes in the modelling of DC systems 672 and 679 (inclusion of battery diversity), while the increase in 2011 resulted from reassessment of fire frequencies. At Olkiluoto NPP, the most important factors affecting the overall accident risk include internal events during power operation (component failures and pipe ruptures leading to an operational transient).

At the end of 2015, the calculated core damage frequency of Olkiluoto 1 was 0.895 x 10^{-5}/year, which is around 6% higher than in 2014 (0.84 x 10^{-5}/year). At the end of 2015, the calculated core damage frequency of Olkiluoto 2 was 1.46 x 10^{-5}/year, which is around 4% higher than in 2014 (1.4 x 10^{-5}/year). The minor changes in core damage frequency are due to specifications made in the PRA models and updated reliability information. The difference between the plant units is mainly caused by the fact that Olkiluoto 1 underwent modifications in 2014 that ensured operability of the auxiliary feedwater system, which is used to cool the reactor, in case seawater cooling is lost because of a blockage at the seawater intake or component failures. Such modifications have not been implemented at Olkiluoto 2 yet.

A.II.5 Number of fire alarms

Definition

As indicators, the number of fire alarms and actual fires are monitored.

Source of data

Data for the indicators is collected from the power companies. The licensees submit the data needed for the indicator to the person responsible for the indicator at STUK.

Purpose

The indicator is used to follow the effectiveness of fire protection at the NPPs.

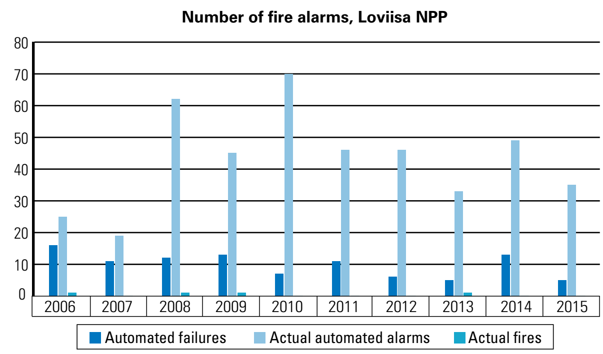
Responsible unit/person

Civil engineering and fire protection (RAK)
Pekka Välikangas

Interpretation of the indicator

No events classified as fires occurred at the Loviisa nuclear power plant (LO1/LO2) in 2015. The rescue personnel had one assignment in the parking area, which is located outside the actual power plant area: they had to extinguish a smouldering passenger vehicle. The number of fire detection system faults and the number of actual alarms made by fire detectors at the Loviisa NPP have remained stable for the past ten years. Alarms from the fire detection systems have also remained at a relatively low level. Most of the alarms were caused by dust, smoke or humidity.

No events classified as fires occurred at the Olkiluoto nuclear power plant (OL1/OL2) in 2015. Three events classified as fires occurred outside the plant area. One of the events occurred in the lorry gate area of the OL3 unit: an electric outlet

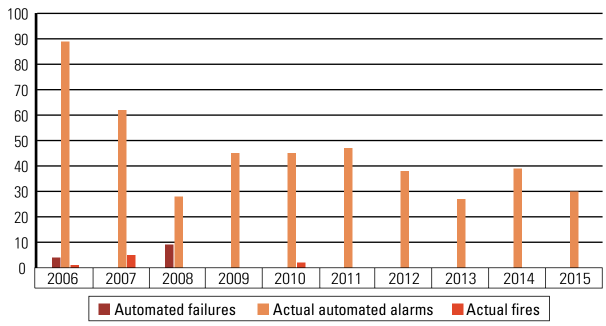


at the bottom of the gate caught fire. TVO's plant fire brigade extinguished the fire with a dry powder extinguisher. The second fire event took place at OL3 construction site area 13 where an IBC container caught fire. TVO's plant fire brigade extinguished the fire with a dry powder extinguisher. The third fire event took place in the parking area of the OL3 construction site where an insulating sheet below a vehicle's body caught fire. The driver of the vehicle extinguished the fire with a dry powder extinguisher. The plant fire brigade was appropriately called to the scene. No fire detection system faults were observed at the Olkiluoto NPP (OL1/OL2) in 2015. No faults were observed during the six past years, either. Correct alarms of the fire detection system have remained at a fairly low level over the past ten years. This lower trend started after the year 2007.

The fire detection system of Loviisa NPP was renovated in 2000 and the fire detection system of Olkiluoto NPP in 2001. After the renovation of the fire alarm systems, the number of alarms increased at both NPPs due to more sensitive detectors. Advance alarms issued by the fire detection system are no longer included in these statistics.

Fire safety at Loviisa and Olkiluoto remained at around the same level as before. There have been four events classified as fires in the Loviisa plant area in the past ten years. The trend for Olkiluoto is decreasing: the last event classified as a fire occurred five years ago. The number of alarms from the fire detection system is affected by the amount of maintenance and repair work performed at the NPPs. Fire detection systems are not always disconnected in a wide enough area during maintenance work.

Number of fire alarms, Olkiluoto NPP



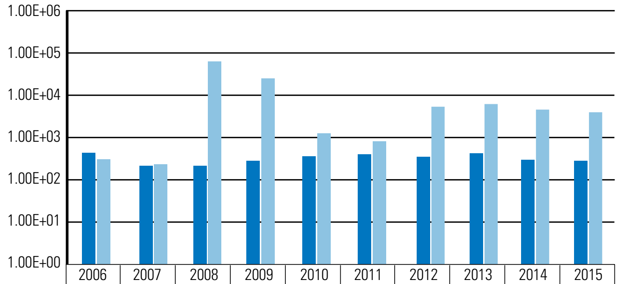
A.III Structural integrity

A.III.1 Fuel integrity

Definition

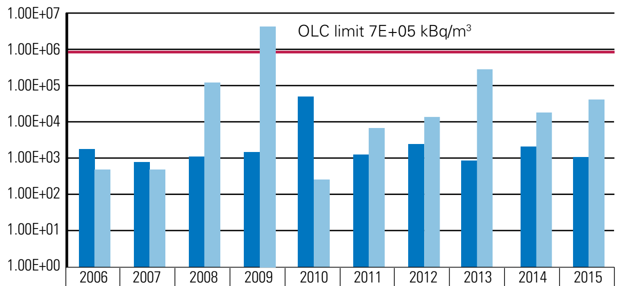
As indicators, the plant unit-specific maximum level and the highest maximum activity value of the iodine-131 activity concentration (I-131 activity concentration) in the primary coolant in steady-state operation (startup operation or load operation for Loviisa and load operation for Olkiluoto) are followed. The change in activity concentration of I-131 in primary coolant due to depressurisation in conjunction with shutdowns or reactor trips, as well as the number of leaking fuel assemblies removed from the reactor, is also followed as an indicator.

Fuel integrity:
Iodine (I-131) maximum activity concentration level of primary coolant (kBq/m³) in power operation, Loviisa NPP



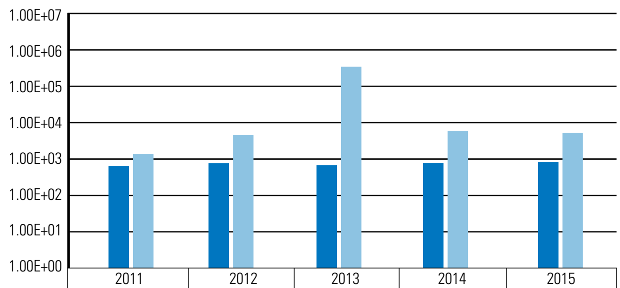
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	3.91E+02	1.90E+02	2.00E+02	2.60E+02	3.80+02	3.90E+02	3.70E+02	4.00E+02	3.50E+02	3.40E+02
LO2	2.72E+02	2.10E+02	4.90E+04	2.40E+04	1.20+03	8.50E+02	4.71E+03	5.40E+03	4.60E+03	3.90E+03

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) in power operation, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	1.90E+03	8.10E+02	1.20E+03	1.54E+03	4.97E+04	1.49E+03	2.80E+03	8.50E+02	2.43E+03	1.12E+03
LO2	5.20E+02	5.00E+02	1.30E+05	3.85E+06	3.20E+03	6.64E+03	1.27E+04	3.41E+05	1.58E+04	3.88E+04

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Loviisa NPP



	2011	2012	2013	2014	2015
LO1	6.70E+02	7.06E+02	6.30E+02	7.60E+02	7.20E+02
LO2	1.40E+03	4.10E+03	3.41E+05	5.00E+03	4.40E+03

Source of data

The licensees submit the indicator values directly to the person in charge of the indicator at STUK. The maximum activity levels are also available in the quarterly reports submitted by the power companies.

Purpose

The indicators describe fuel integrity and the fuel leakage volume during the fuel cycle. The indicators for shutdown situations also describe the success of the shutdown in terms of radiation protection.

Responsible unit/person

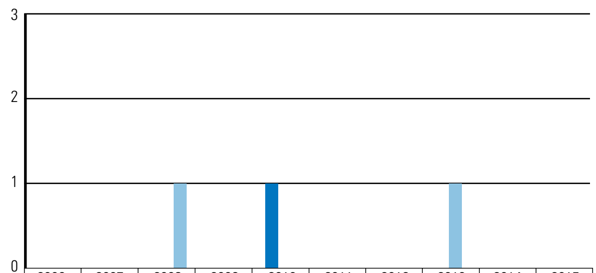
Reactor and Safety Systems (REA),
Dina Solatie

A.III.1a Reactor coolant system activity

Interpretation of indicators (Loviisa)

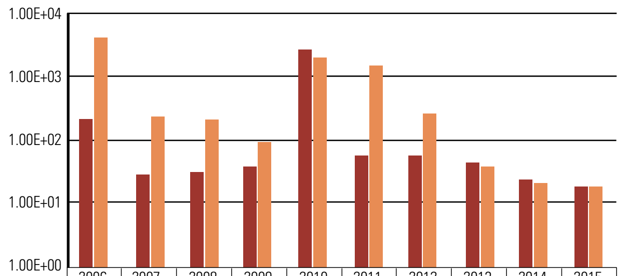
There were no leaking fuel assemblies in the reactor of Loviisa 1 in 2015. The last time a leaking fuel assembly was removed from the Loviisa 1 reactor was in 2013 and the last time a leaking fuel assembly was removed from Loviisa 2 was during the annual outage of 2013. As a result of these measures, the maximum activity (I-131) of the primary coolant has remained low. After removal of the leaking fuel assemblies, the maximum activity values associated with shutdowns also returned to the level before the leaks. The actual reason for the fuel leak in Loviisa 2 is still unknown, as examination of the damaged fuel assemblies has not been possible due to problems with the pool inspection equipment. All in all, the fuel integrity at both Loviisa plant units was good in 2015.

Number of leaking fuel bundles removed from the reactor, Loviisa NPP



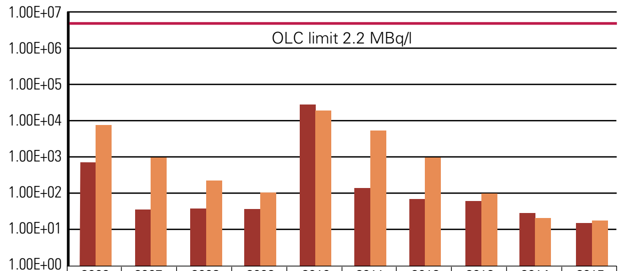
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0	0	0	0	1	0	0	0	0	0
LO2	0	0	0	1	0	0	0	1	0	0

Fuel integrity: Iodine (I-131) maximum activity concentration level of primary coolant (kBq/m³) in power operation, Olkiluoto NPP



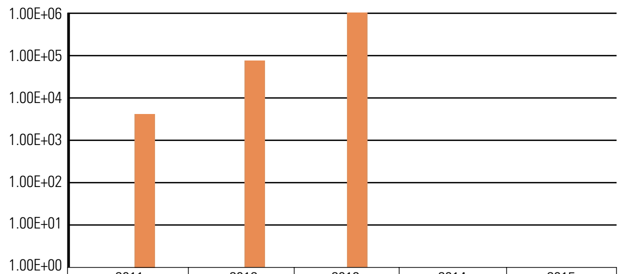
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	2.00E+02	2.70E+01	3.00E+01	3.50E+01	2.45E+03	5.50E+01	5.58E+01	3.92E+01	2.55E+01	1.94E+01
OL2	4.00E+03	2.30E+02	2.10E+02	9.10E+01	1.87E+03	1.46E+03	3.03E+02	3.43E+01	2.13E+01	1.94E+01

Fuel integrity: Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³), Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	6.90E+02	3.50E+01	3.70E+01	3.60E+01	3.12E+04	1.40E+02	6.76E+01	5.90E+01	3.16E+01	2.24E+01
OL2	7.03E+03	9.99E+02	2.30E+02	1.00E+02	2.01E+04	4.84E+03	9.45E+02	9.51E+01	2.53E+01	2.38E+01

Fuel integrity: Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Olkiluoto NPP

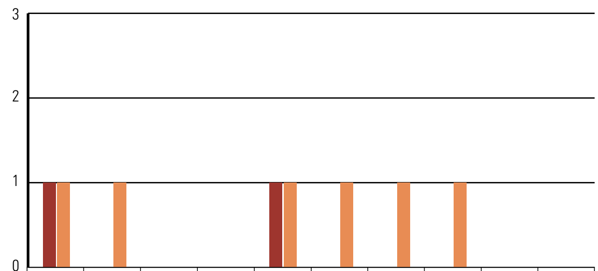


	2011	2012	2013	2014	2015
OL1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OL2	3.93E+03	6.19E+04	1.00E+06	0.00E+00	0.00E+00

Interpretation of indicators (Olkiluoto)

There were no leaking fuel assemblies in the reactor of Olkiluoto 1 in 2015. Thus, the primary coolant activity caused by iodine-131 at Olkiluoto

Number of leaking fuel bundles removed from the reactor, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	1	0	0	0	1	0	0	0	0	0
OL2	1	1	0	0	1	1	1	1	0	0

1 has continued to decrease since 2010. On the basis of other inspections carried out during the annual outage, the fuel types at both plant units have mostly behaved normally. Several fuel leaks have occurred in the 2000s at Olkiluoto 2. Most of the leaks have been caused by small loose objects entering the reactor during maintenance operations. The coolant flow may cause the loose objects to vibrate and break the fuel cladding. To minimise the problem, new Triple Wave+ foreign object sieves have been adopted at Olkiluoto 2.

A.III.1b Number of leaking fuel assemblies

All leaking fuel assemblies are removed during annual outages. Both licensees use an external party when identifying leaking assemblies. This means that a subcontractor handles the actual equipment and provides the operators, but the plant's own radiochemistry laboratory analyses the water samples from the reactor. The leaking fuel assembly is identified based on the analysis results.

Interpretation of indicators (Loviisa)

There was no leaking fuel in the reactors of Loviisa 1 or Loviisa 2 during the period under review.

Interpretation of indicators (Olkiluoto)

There was no leaking fuel in the reactors of Olkiluoto 1 and Olkiluoto 2 in 2015.

A.III.2 Reactor coolant system integrity

A.III.2a Water chemistry conditions

Definition

As indicators, the water chemistry conditions for each plant unit are followed.

The water chemistry indicators are:

- Chemistry performance indices used by the licensees, depicting the effectiveness of water chemistry control in the secondary circuits of PWRs and in the reactor circuits of BWRs. The chemical conditions in the secondary circuit of a pressurized water reactor affect the integrity of the interface between the reactor coolant system and the secondary circuit. The indicator for Loviisa is a new index developed at the NPP to be used together with the international index. The new index describes the water chemistry conditions in the secondary circuit at Loviisa with a higher degree of sensitivity than the corresponding international index for VVER plants. The indicator for Olkiluoto is the international index used by the NPP. The Loviisa index observes corrosive factors and the concentrations of corrosion products in the steam generator blowdown and the feedwater. For steam generator blowdown, the calculation includes the chloride, sulphate and sodium concentrations and acid conductivity. For feedwater, it includes the iron, copper and oxygen concentrations. The chemistry index of Olkiluoto consists of the chloride and sulphate concentrations of the reactor water and the iron concentration in the feedwater. The indices for both NPPs only cover the aforementioned parameter values during load operation.
- The maximum chloride concentration of the steam generator blowdown at the Loviisa plant units and the reactor water at the Olkiluoto plant units during operation compared with the OLC limit in the monitoring period. At Olkiluoto, the maximum sulphate content of reactor water during steady-state operation is also followed.
- Corrosion products released from the surfaces of the reactor coolant system and the secondary circuit into the coolant. For the Loviisa NPP, the iron concentration of the reactor coolant and the secondary circuit feedwater (maximum values for the monitoring period) are followed. For Olkiluoto NPP, the iron concentration of feedwater (maximum value for the monitoring period) is followed. In addition, the maximum Co-60 activity concentration in the reactor coolant while bringing the plant to a cold shutdown or after a reactor trip is followed for both NPPs.

Source of data

The licensees submit indicators describing water chemistry control to the respective responsible person at STUK. The approximate concentration levels of corrosive substances and corrosion products can also be obtained from quarterly reports submitted by the licensees.

Purpose

The water chemistry indicators are used to monitor and control the integrity of the reactor coolant system and the secondary circuit. The monitoring is done by indices depicting the maintenance of water chemistry and by following selected corrosive impurities and corrosion products. The water chemistry indices combine a number of water chemistry parameters and thus give a good overview of the water chemistry conditions. STUK's indicators are also used to monitor the fluctuation of certain parameters in more detail. The corrosive substances monitored include chloride and sulphate. The corrosive products followed are iron and radioactive Co-60. The activity concentration of Co-60 isotope while bringing the plant to a cold shutdown is used to describe the access of cobalt-containing structural materials into the reactor circuit and the success of the water chemistry control and the shutdown procedures. In addition to the parameters described here, the licensees use several other parameters to monitor the water chemistry conditions of the plant units.

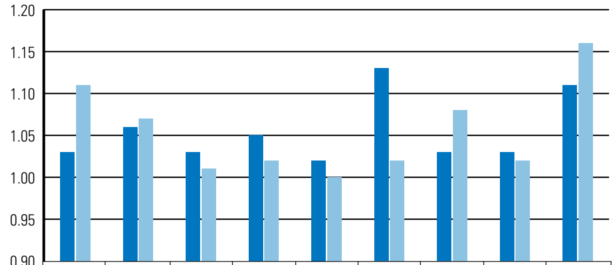
Responsible units/persons

Reactor and safety systems (REA),
Dina Solatie

Interpretation of indicators (Loviisa)

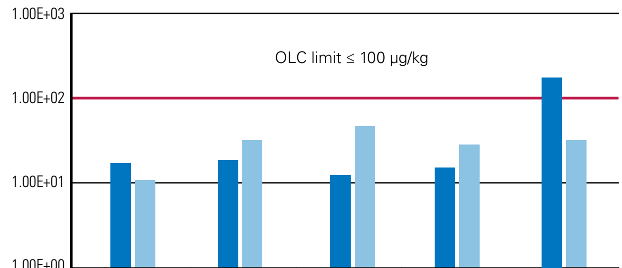
In the past few years, the chemistry index has remained at a good level at the Loviisa plant units. The blowdown water chlorine content was slightly higher than during the previous year at Loviisa 1 due to a seawater leak. The leaking tube was plugged quickly, however. The iron content of the secondary circuit feedwater was normal in 2015. The figures show that the most clearly discernible change from previous years is the high iron concentration in the secondary side feedwater at Loviisa 2. This was a brief transient (one measuring result) and thus it does not have a major

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



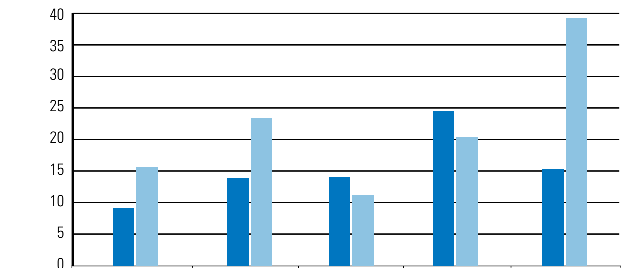
	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	1.03	1.06	1.03	1.05	1.02	1.13	1.03	1.03	1.11
LO2	1.11	1.07	1.01	1.02	1.00	1.02	1.08	1.02	1.16

Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration of a steam generator blow-down (µg/kg) in power operation, Loviisa NPP



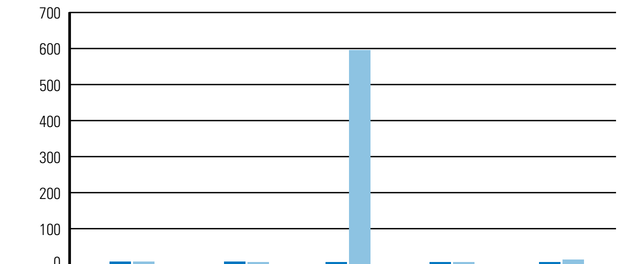
	2011	2012	2013	2014	2015
LO1	1.93E+01	1.98E+01	1.36E+01	1.81E+01	2.24E+02
LO2	1.10E+01	3.19E+01	4.30E+01	3.00E+01	3.17E+01

Integrity of primary circuit: Corrosion products; Maximum iron concentration in primary coolant (Fe-tot µg/l) in power operation, Loviisa NPP



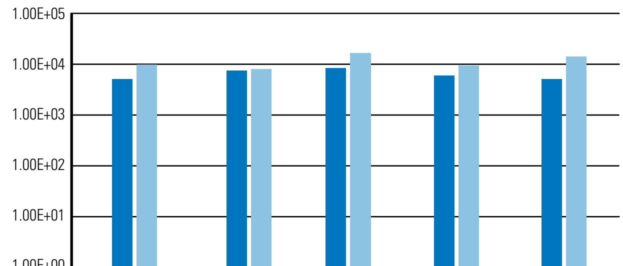
	2011	2012	2013	2014	2015
LO1	9.1	13.8	14.1	24.5	15.3
LO2	15.7	23.4	11.2	20.4	39.3

Integrity of primary circuit: Corrosion products; Maximum iron concentration in the feed water (µg/l) (RL30 / RL70) in power operation, Loviisa NPP



	2011	2012	2013	2014	2015
LO1	8.1	8.4	7.4	6.7	6.7
LO2	8.4	7.7	596.0	6.6	14.8

Integrity of primary circuit: Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Loviisa NPP



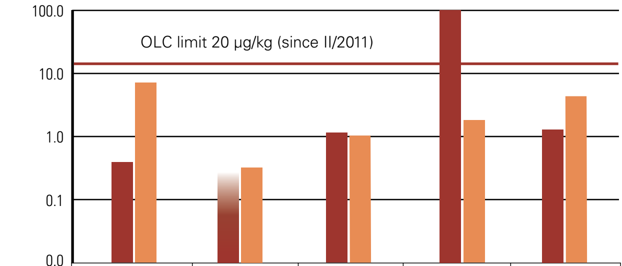
	2011	2012	2013	2014	2015
LO1	5.26E+03	7.48E+03	8.10E+03	5.40E+03	5.40E+03
LO2	9.88E+03	7.90E+03	1.40E+04	9.10E+03	1.34E+04

impact on the corrosion behaviour of the steam generator pipes in the long term or the integrity of the reactor coolant system. The iron content in the secondary side feedwater returned to normal in 2014 and 2015. The maximum Co-60 activity levels associated with shutdowns were measured during shutdowns for annual outages. In 2015, the concentrations were around the same as in the previous years, which indicates successful compliance with the ALARA principle. The indicator shows that the integrity of the reactor coolant systems of the Loviisa plant units was acceptable in 2015

Interpretation of indicators (Olkiluoto)

The impurity and corrosion product levels in reactor water and feedwater, followed in STUK's indicator scheme, remained below the OLC limits at Olkiluoto 2. In 2015, the chemistry index for Olkiluoto 1 was the best possible: 1. The chemistry index for Olkiluoto 2 was higher due to a seawater leak in a condenser. Iron, sulphate and chloride contents of the reactor coolant did not deviate from their regular values at Olkiluoto 1 in 2015, which is also shown by the achieved chemistry index value. The monitoring and optimisation of Olkiluoto 2 water chemistry was also successful in 2015. At both plant units, the shutdown-related maximum value of Co-60 activity concentration occurred during shutdowns for annual outages. There were no essential changes in the Co-60 activity concentration compared to previous years, which indicates successful compliance with the ALARA principle. The indicator shows that reactor coolant system integrity was good at the Olkiluoto plant units in 2015.

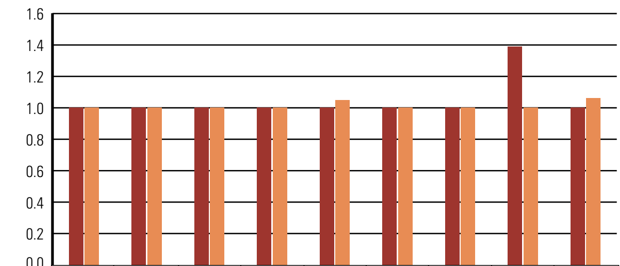
Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration in primary coolant (µg/kg) in power operation, Olkiluoto NPP



	2011	2012	2013	2014	2015
OL1	0.7	0.5	1.1	102.0	1.4
OL2	7.8	0.6	1.0	2.5	4.5

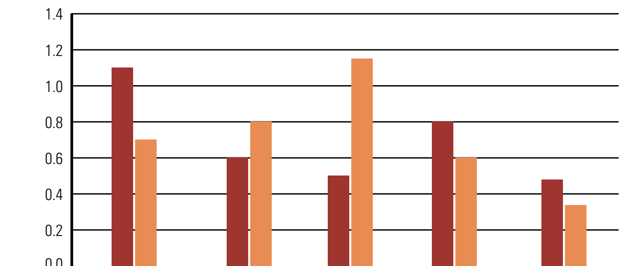
below detection limit

Integrity of primary circuit: Chemistry index, Olkiluoto NPP



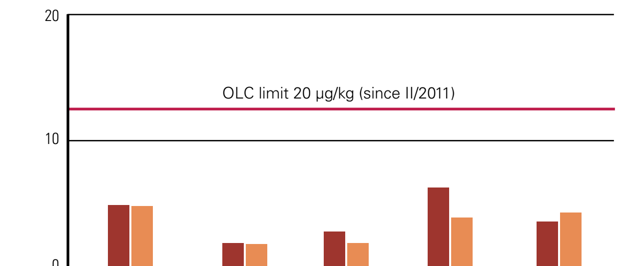
	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.39	1.00
OL2	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00	1.06

Integrity of primary circuit: Corrosion products; Maximum iron concentration in reactor feed water (µg/l) in power operation, Olkiluoto NPP



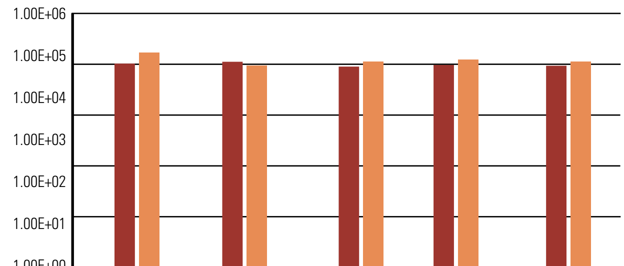
	2011	2012	2013	2014	2015
OL1	1.10	0.60	0.50	0.80	0.48
OL2	0.70	0.80	1.15	0.60	0.34

Integrity of primary circuit: Corrosion products; Maximum sulphate concentration in primary coolant (µg/l) in power operation, Olkiluoto NPP



	2011	2012	2013	2014	2015
OL1	4.9	1.9	2.8	6.3	3.6
OL2	4.8	1.8	1.9	3.9	4.3

Integrity of primary circuit: Corrosion products; Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Olkiluoto NPP



	2011	2012	2013	2014	2015
OL1	1.10E+05	1.19E+05	8.65E+04	9.91E+04	9.80E+04
OL2	2.66E+05	9.05E+04	1.19E+05	1.34E+05	1.24E+05

A.III.2b Reactor coolant system leakages (Olkiluoto)

Definition

The indicators below are used to follow identified and unidentified reactor coolant system leakages at the Olkiluoto plant units:

- Total volume (m3) of identified (from containment to collection tank 352 T1 of the controlled leakage drain system) and unidentified (total volume of leakages into the sump of the controlled floor drainage system, 345 T33) internal leakages in the containment during the fuel cycle.
- Highest daily internal leakage volume in the containment during the fuel cycle in relation to the leakage volume allowed in the OLC (outflow water volume of water condensing in the air coolers of the containment cooling system 725/ OLC limit).

Source of data

The licensee submits data on reactor coolant system leakages at the Olkiluoto NPP to the person responsible at STUK.

Purpose

The indicator describing reactor coolant system leakages is used to follow and monitor the leak rate of the reactor coolant system within the containment.

Responsible units/persons

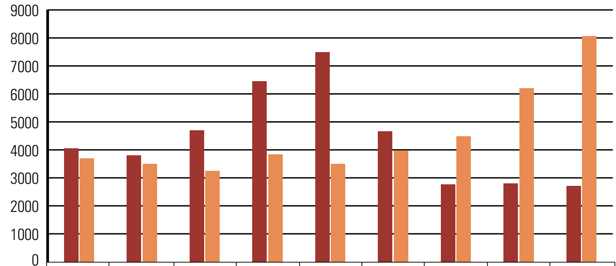
Operational safety (KÄY), Jukka Kallionpää

Interpretation of the indicator, fuel cycle 2013–2014

One of the purposes of controlled leakage K352 is to collect leakages from valves, pumps and other similar components. The drains from the seal boxes of the valves within the containment are equipped with temperature sensors to locate any leaks. Temperature sensors installed on the drains above the main lines will detect any leakage in the specific line. Other methods must then be used to locate the actual leaking object. Identified leaks within the containment increased to some extent at OL1 in 2009, 2010 and 2011. They decreased in 2012, continued to decrease in 2013 and remained at the same level in 2015. The number of identified leaks at OL2 somewhat increased in 2014 and 2015. The leakage volumes do not include the drainage of process systems during annual outages and other outages. The identified leaks include sampling flows of approximately 100–1,500 m³ from the reactor building.

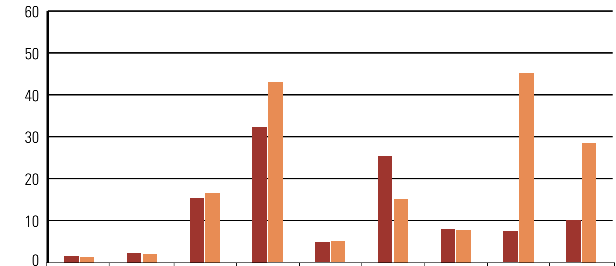
At the lowest point of the containment drywell, there is the drain water pit T33, which collects the drain water from the containment drywell floor drains and any leakage from the control rod actuator seals. The volumes of unidentified reactor coolant system leaks during the operating cycle 2010–2011 decreased at both plant units. In 2012, they increased slightly from the 2011 level at both plant units, only to fall back to the previous level in 2013. Unidentified leaks at OL1 remained at the 2013 level in 2014, but unidentified leaks at OL2 increased to the level of 2010. In 2015, unidentified leaks at OL2 decreased to approximately half of the 2014 level.

Identified leakages of primary circuit (352T1, m³), Olkiluoto NPP



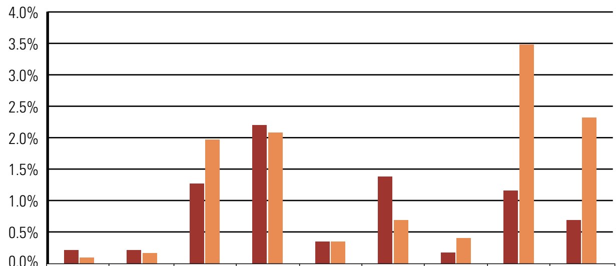
	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	4058	3805	4697	6448	7496	4664	2773	2810	2715
OL2	3696	3502	3252	3847	3506	3973	4489	6195	8065

Unidentified leakages of primary circuit (345T33, m³), Olkiluoto NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	1.56	2.16	15.48	32.28	4.74	25.30	7.90	7.38	10.14
OL2	1.26	2.04	16.50	43.08	5.10	15.20	7.70	45.12	28.44

The maximum unidentified leakage in ratio to the OLC limit, Olkiluoto NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.21	0.21	1.27	2.20	0.35	1.38	0.17	1.16	0.69
OL2	0.09	0.16	1.97	2.08	0.35	0.69	0.40	3.48	2.32

One of the purposes of containment gas cooling system 725 is to remove moisture from the containment atmosphere. Moisture may originate from steam leaking from the reactor coolant system. During the fuel cycle of 2013–2014, the ratio of the containment's largest internal daily leak volume to the maximum allowable volume, as specified in the OLC, was low at both plant units.

The reactor coolant system was relatively leak-proof during the 2014–2015 fuel cycle.

A.III.3 Containment integrity

Definition

As indicators, the following parameters are monitored:

- Total as-found leakage of outer isolation valves following the first integrity tests compared with the maximum allowed total leakage from the outer isolation valves.
- Percentage of isolation valves tested during the year in question at each plant unit that passed the leak test at the first attempt (i.e. as-found leakage smaller than the acceptance criteria of the valve and no consecutive exceeding of the attention criteria of a valve without repair).
- Combined as-found leakage rate of containment penetrations and airlocks in relation to their maximum allowed total leakage. The combined leakage rate at Olkiluoto includes leaks from personnel airlocks, the maintenance dome and the containment dome. At Loviisa, the combined leakage rate comprises the leak test results from personnel airlocks, the material airlock, cable penetrations of inspection equipment, containment maintenance ventilation systems (TL23), main steam piping (RA) and feedwater system (RL) penetrations; seals of blind-flanged penetrations in ice-filling pipes are also included.

Source of data

Data is obtained from the power companies' leak-tightness test reports that are submitted by the licensees to STUK for information within three months from the completion of an annual outage. STUK calculates the total as-found leakages, since the reports give total leakages as they are at the end of the annual outage (i.e. after the completion of repairs and re-testing).

Purpose

This indicator is used to monitor the integrity of containment isolation valves, penetrations and airlocks.

Responsible unit/person

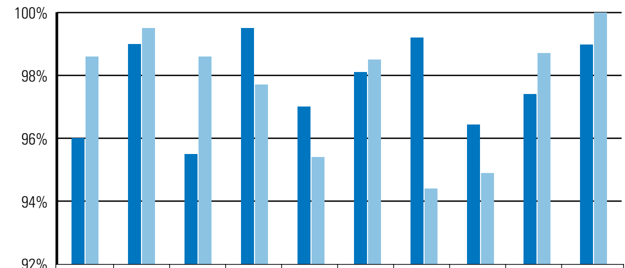
Reactor and safety systems (REA),
Päivi Salo

Interpretation of the indicator

Loviisa

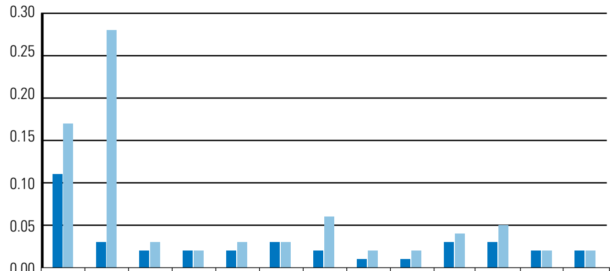
Total leakage of the outer isolation valves compared to the maximum allowed total leakage remained unchanged at both plant units. The as-found leakage of both units remains clearly below the set limit.

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



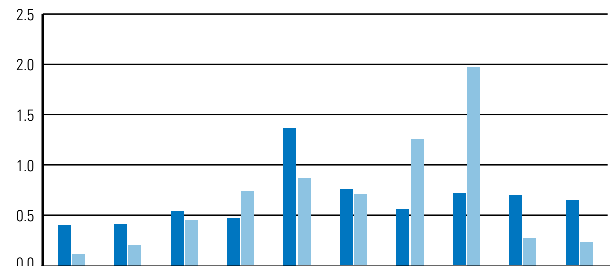
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	96.0	99.0	95.5	99.5	97.0	98.1	99.2	96.4	97.4	99.0
LO2	98.6	99.5	98.6	97.7	95.4	98.5	94.4	94.89	98.7	100.0

Combined leak rate of containment penetrations and air locks compared to the leak limit, Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0.11	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.03	0.03	0.02	0.02
LO2	0.17	0.28	0.03	0.02	0.03	0.03	0.06	0.02	0.02	0.04	0.05	0.02	0.02

The overall as-found leakage of outer isolation valves compared with the highest allowed overall leakage of outer isolation valves, Loviisa NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
LO1	0.40	0.41	0.54	0.47	1.37	0.76	0.56	0.72	0.70	0.65
LO2	0.11	0.20	0.45	0.74	0.87	0.71	1.26	1.97	0.27	0.23

The number of isolation valves that passed the leak test at first attempt has increased in both plant units.

Overall as-found leakage rate of containment penetrations and airlocks is low at both plant units.

The total as-found leakage rate of containment penetrations, in which TVO includes leakages in the upper and lower personnel airlocks, the maintenance dome and the containment dome, has increased but is still small for both plant units.

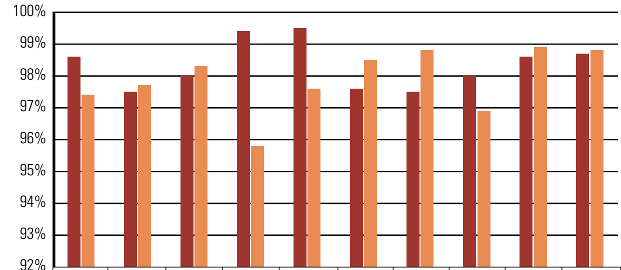
Olkiluoto

The total as-found leakages of outer isolation valves at the Olkiluoto 1 plant unit has somewhat decreased. It was clearly below the as-found leakage limit set in the operational limits and conditions.

The overall as-found leakage of the outer isolation valves of Olkiluoto 2 increased when compared to the previous year, but remained clearly below the limit set in the OLC.

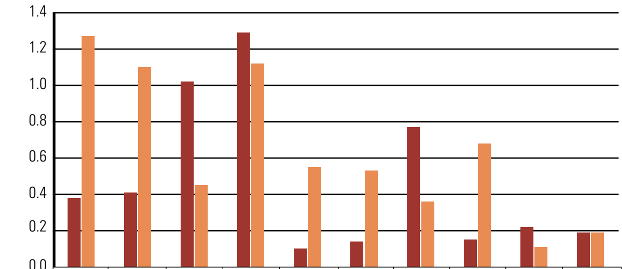
The percentage of isolation valves that passed the leak test at first attempt remained high for both plant units.

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



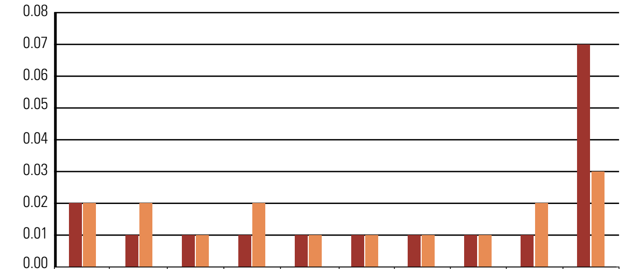
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	98.6	97.5	98.0	99.4	99.5	97.6	97.5	98.0	98.6	98.7
OL2	97.4	97.7	98.0	95.8	97.6	98.5	98.8	96.9	98.9	98.8

The overall as-found leakage of outer isolation valves compared with the highest allowed overall leakage of outer isolation valves, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.38	0.41	1.02	1.29	0.10	0.14	0.77	0.15	0.22	0.19
OL2	1.27	1.10	0.45	1.12	0.55	0.53	0.36	0.68	0.11	0.19

Combined leak rate of containment penetrations and air locks compared to the leak limit, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OL1	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07
OL2	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.03

APPENDIX 3 Significant events at nuclear power plants in 2015

Loviisa NPP

Wrong relays in rectifiers at Loviisa

An electromechanical switch (i.e. relay) of the wrong type was observed in a rectifier at the Loviisa NPP during the four-year annual outage on 13 January 2015. During an inspection conducted after the observation, it was noted that similar relays of the wrong type had been installed in five other rectifiers as well. The rectifiers were installed in 2008 and 2009, and no deficiencies in their operation have been observed.

The relays protect rectifiers from power grid transients. The rectifiers charge safety-relevant battery banks, which are used to provide redundant power supply for I&C components. In case of a rectifier failure, the battery banks will supply power to the I&C components for several hours.

Loviisa NPP immediately replaced the wrong relays with relays of the correct type. However, the new relays still include components which have not been approved. In terms of these deficiencies, Loviisa NPP submitted a detailed further action plan to the Radiation and Nuclear Safety Authority for approval. Most of the relays were replaced during the 2015 annual outage according to plan. The rest of the relays in the rectifiers of the Loviisa 2 emergency diesel generator system will be replaced during the 2016 annual outage.

The wrong relay type has not compromised the safe operation of the plant. The event did not have any safety significance and on the INES scale it is rated as a level 0 event.

Failures in Loviisa 2 control rod drive mechanisms

On Thursday, 5 November 2015, one of the control rods in Loviisa 2 dropped into the reactor, which decreased reactor power. The control rod dropped because of a motor failure in the control rod mechanism. Fortum shut down the unit on Friday, 6 November to perform additional checks and repairs. Based on measurements carried out on the other motors, Fortum finally decided to replace four control rod mechanism motors with

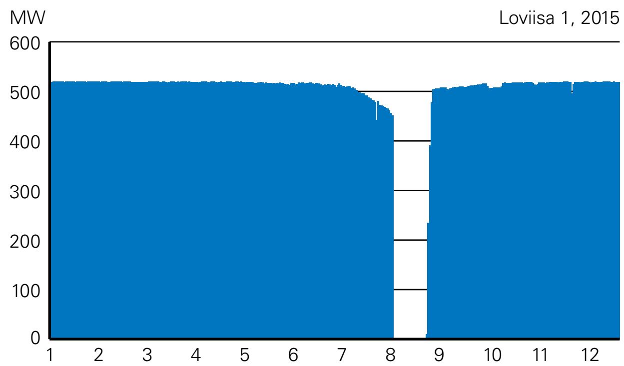


Figure A3.2. Daily average gross electrical power of the Loviisa 1 plant unit in 2015.

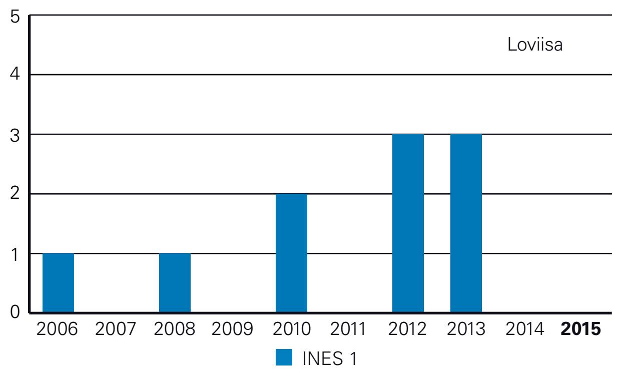


Figure A3.1. INES classified events at the Loviisa plant (INES Level 1 or higher).

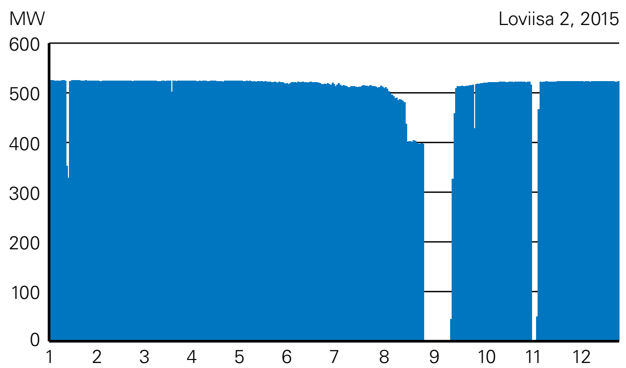


Figure A3.3. Daily average gross electrical power of the Loviisa 2 plant unit in 2015.

spare motors approved by STUK. STUK inspected and approved the modification, and ensured that the necessary tests were completed and approved during unit startup. The unit was restarted on 9 November 2015 once the repairs were complete.

The event did not influence the ability to shut down the reactor or compromise plant safety.

Annual outage 2015 of Loviisa 1

The refueling outage of Loviisa 1 was completed safely and all scheduled work was completed. The only work that was postponed according to plan was the radiation measuring (RA measuring) of the main steam line, which will be completed before the 2016 outage. Approximately one-quarter of the fuel was replaced. The outage took around 21.5 days, i.e. around three days more than planned. The delay was caused by a delay in the replacement of reheaters in the turbine island steam lines.

A hydrogen leak was observed in one of the turbine-generators (TG2 SP50) during the startup. The leak was repaired. Hydrogen had leaked during the two previous fuel cycles.

In addition to the refueling, major modifications included installation of steam generator surface level measuring nozzles and modernisation of turbine reheaters. Plenty of preparatory work for the Loviisa I&C renewal project (ELSA) was completed in anticipation of changes to be realised during the 2016 annual outage.

Furthermore, cooling towers built in 2014–2015 were commissioned during the annual outage. In case seawater supply is lost, the cooling towers can be used to cool safety-relevant systems and remove residual heat from the reactor. The towers are one of the renewals to be completed because of the Fukushima accident.

During the annual outage, the power company reported three events to STUK where work was not completed fully in compliance with the operational limits and conditions at Loviisa 1. In the first event, an acoustic alarm that is used as an additional alarm for the refueling machine was switched off for a short period of time at the beginning of refueling, because the switch had not been turned to the right position. In the second event, a shield plate of one of the recombiners (that are used in case of an accident to exhaust hydrogen from the containment) was accidentally left in place during startup. In the third event, the maintenance of a pump in a safety system shared by Loviisa 1 and Loviisa 2 was started before Loviisa 1 was switched to load operation (Loviisa 2 had already been shut down) – the separation in itself is not the problem, but the operational limits and conditions state that all safety-relevant devices must be ready for operation when switching to load operation. None of the events compromised the safety of the plant, the environment or the employees, and the events were rated as level 0 events on the INES scale.

The total radiation dose at Loviisa 1 was 237.85 man-mSv, which is the lowest total radiation dose ever measured during the history of the unit. The largest measured individual dose was 3.9 mSv. The employee received this does when installing the YB surface level measuring nozzles.

Annual outage 2015 of Loviisa 2

The maintenance outage of Loviisa 2 was completed safely and all the scheduled works were completed. Approximately one-quarter of the fuel was replaced. The outage took around 17 days, which complied with the action plan.

In addition to the refueling, major modifications included installation of steam generator surface level measuring nozzles and modernisation of turbine reheaters. Plenty of preparatory work for the Loviisa I&C renewal project (ELSA) was completed in anticipation of changes to be realised during the 2016 annual outage. New main steam piping radiation measurements (RA measurements) were installed at Loviisa 2. During commissioning tests at the unit, it was observed that the setpoints of the new measurements are such that the measurements may fail to detect minor primary-secondary leaks. STUK required that the issue involving the operability of the measurements be processed as an application for an exemption from the OLC. More work on the primary circulating pumps than normal was performed. One of the diesel generators in Loviisa 2 underwent a "17-year maintenance" (where the motor was also replaced).

Vibration of one of the reactor coolant pumps in Loviisa 2 increased on 17 August 2015 and the pump was switched off a little less than two weeks prior to the start of the annual outage. YD14 pumps in both plant units were replaced with pumps that had undergone maintenance during the annual outage. The internals of the YD14 pump removed from Loviisa 1 were dismantled and inspected during the annual outage of Loviisa 2. Based on the damage observed, one can state that some of the pump's internal components that should not rotate had started to rotate. The damage observed in the internals of the YD14 pump from Loviisa 2 was more extensive than the damage observed in the YD14 pump of Loviisa 1. Due to the damage, STUK requested an assessment from Fortum of the safety significance of the event, including the causes of the damage, the probability of such damage occurring during the next fuel cycle, as well as how the event influenced radiation safety and the integrity of the nuclear fuel (due to loose components in the primary circuit after the event, for example). The matter was processed as part of the Loviisa 2 startup permit application. STUK did not have any remarks about the report and the plant unit could be started. The pump was repaired and Fortum removed any excess solids from the primary circuit with a cleaning cycle during the beginning of the startup. The pumps and the wearing of their spare parts will be reviewed as part of the ageing management surveys required by STUK.

The total radiation dose at Loviisa 2 was 223.28 man-mSv, which is the second lowest total radiation dose ever measured during the history of the unit. The largest measured individual dose was 4.5 mSv. The employee received this does when installing the YB surface level measuring nozzles.

Olkiluoto nuclear power plant

Olkiluoto 2 shut down due to humidity in a generator

A water leak was observed in a water-cooled generator at Olkiluoto 2 on 4 February 2015, which is why the plant unit was disconnected from the national grid. Despite joint efforts of TVO and the generator supplier, the water leak could not be located and a decision to initiate a cold shutdown was made. During the shutdown, it was decided that the generator rotor would be replaced. Verifying the leak in the rotor in the field was not possible, but all other potential leak sources could be excluded with high probability by means of helium testing. The rotor was sent to the generator supplier factory for further studies. After the fairly extensive work on the generator, the plant unit was reconnected to the national grid on 24 February 2015. It reached full power on 25 February 2015.

Open penetrations in containment during annual outage work done on the reactor coolant pumps

In December, TVO submitted to STUK for approval an operational event report regarding an exceptional event that influenced safety. It was connected to work done during the annual outages of Olkiluoto nuclear power plant in 2013–2015.

At both currently operating units of Olkiluoto NPP, preparations have been made in case of a very unlikely situation during work done on a re-

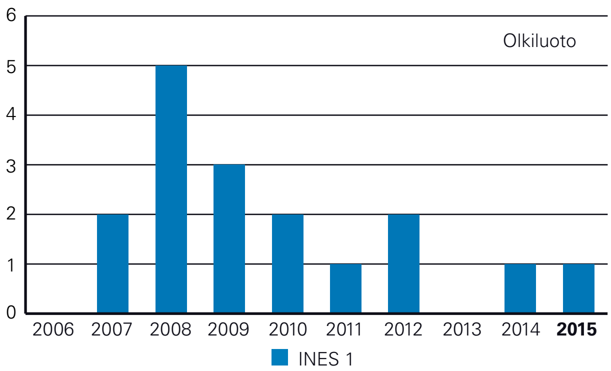


Figure A3.4. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

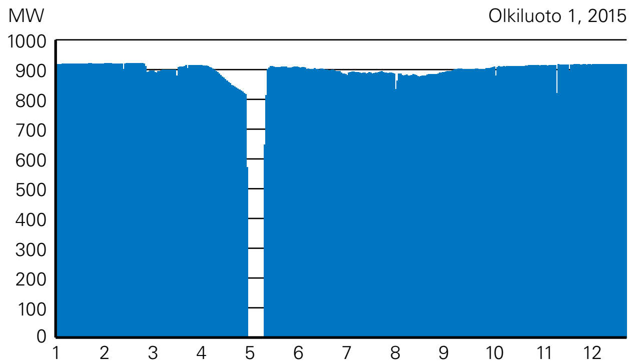


Figure A3.5. Daily average gross power of the Olkiluoto 1 plant unit 2015.

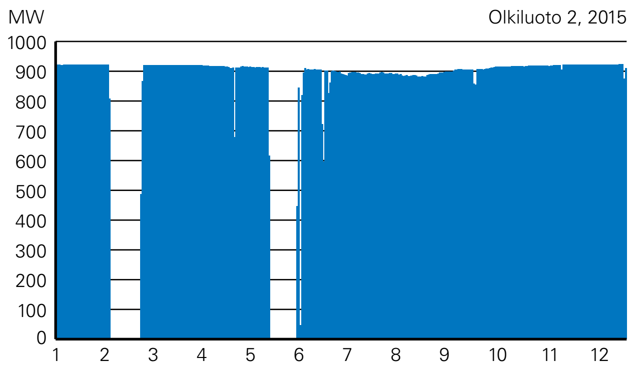


Figure A3.6. Daily average gross power of the Olkiluoto 2 plant unit 2015.

actor coolant pump in connection with an annual outage where a leak occurs at the bottom of the reactor through the bushing of the reactor coolant pump's shaft. The units' operational limits and conditions demand the opportunity to pump a sufficient amount of make-up water in case of a leak under such conditions to ensure cooling of the fuel in the reactor.

In October 2015, TVO observed that some electrical penetrations in the containment were replaced when performing work on the reactor coolant pumps during the annual outages of 2013–2015. Had there been a leak at the bottom of the reactor through the shaft bushing when the electrical penetrations were open, more pumps to supply make-up water than required by the units' operational limits and conditions would have been needed to ensure cooling of the fuel in the reactor. Other systems would have been available to supply the required make-up water, however. In the future, TVO will change its instructions in such a manner that one of the prerequisites for starting work on the reactor coolant pumps is not having any open penetrations or any other routes at the reactor coolant pump level or below the reactor coolant pump level through which water could leak to the area below the lower drywell.

The event did not cause any immediate nuclear or radiation safety risks. On the seven-tier International Nuclear Event Scale (INES), the event is rated as level 1, i.e. it is classified as an anomaly, an incident affecting safety.

Crack in a feedwater nozzle at Olkiluoto 2

The crack in a feedwater nozzle at Olkiluoto 2 is located in a weld in between the reactor pressure vessel nozzle butt weld and its joint (safe-end) on the inside of the nozzle. The crack may be a manufacturing fault that was originally left undetected and whose actual depth could not be determined until before new inspection techniques were introduced. On the other hand, the crack may also be a fault caused by stress corrosion that has grown over time and may continue to grow. The crack was detected in 2003 and has been monitored ever since. During the 2013 annual outage, TVO had the area of the crack inspected from the outside by means of phased array ultrasonic testing. The depth of the internal crack was determined as 23 mm (wall thickness 33 mm). The inspection result was a surprise: the depth of the crack was given as 23 mm compared to the 10–15 mm that had been determined with the inspection techniques used before. During the 2013 annual outage, STUK approved a strength analysis submitted by TVO and a procedure where the crack would be monitored for the next three years.

According to inspections made during the 2015 annual outage, the crack has not grown. TVO has installed a leak detection system that is based on temperature in the area during the annual outage. TVO has already made preparations for repairing the crack. According to the submitted repair plan, the feedwater nozzle will be plugged from the reactor side and the feedwater piping will be cut at a pipe bend outside the biological shield before repairing the crack.

Cracks at pipeline mixing points

In an inspection implemented during the 2014 annual outage of Olkiluoto 2, several cracks were detected in feedwater line 1 and one crack was detected in feedwater line 2. Several cracks at a similar mixing point were also found during an inspection of feedwater line 2 at Olkiluoto 1. In its decisions, STUK required replacement of the cracked pipe sections during the 2015 annual outages. These pipeline mixing points were replaced in 1986.

The cracks are at a mixing point of pipelines from the feedwater system and the reactor coolant system where flows at different temperatures mix. The mixing flows cause continuous temperature fluctuation of the structural material when the unit is in hot standby or low power feedwater control mode. This means that the mixing point is subjected to fatigue.

During the 2015 annual outages, both mixing points were replaced at Olkiluoto 2 and one of the two mixing points was replaced at Olkiluoto 1. The cracked mixing point at Olkiluoto 1 was replaced and the other mixing point was inspected. No new indications were found in the inspected mixing point, and it will be replaced during the 2016 annual outage.

STUK oversaw the planning of the replacement, manufacture and installation. During the annual outage, STUK's mechanical equipment inspectors performed inspections at the worksite in compliance with the inspection plan and oversaw the work in general. The installation work was successful and the installations were mostly completed on schedule. The final result complies with the plans both structurally and in terms of quality.

Annual outage of Olkiluoto 1 (3–14 May 2015)

The refueling outage of Olkiluoto 1 was completed safely and all the scheduled works were completed. Approximately one-fifth of the fuel was replaced. The outage took around 10.5 days, i.e. it was 1.5 days longer than expected. The delay was caused by disassembly of the reactor and problems when performing a pressure test during the replacement of a feedwater line mixing point.

In addition to the refueling, major maintenance work included replacement of mixing points in the feedwater line and reactor cooling line, as well as replacement of one reactor coolant pump. The replacement of the mixing point proceeded well up until the pressure test. According to the mixing point's quality plan, the new mixing point had to be pressure tested at 110.5 bar. However, leaktightness of the feedwater line maintenance valves, which formed the pressure boundary of the pressure test, was not sufficient to raise the pressure to the required level: the pressure could only be increased to around 52 bar. STUK was of the opinion that completing the pressure test as planned was the primary operating model in this case and required that TVO come up with a solution to perform the test. TVO was finally able to successfully perform the pressure test with a new pump.

Initial inspections of two new ATRIUM 11 test fuel assemblies and channels revealed a problem connected to re-channeling of the assembly after the inspections. Due to a faulty contact between a guide installed in the channel and the assembly gripper of the refueling machine, the assembly that was inspected first could not be completely lowered back into the channel, which is why the assembly was placed in the fuel pool without the channel. Only one of the planned test fuel assembly inspections could be completed due to this event. The corresponding symmetry assembly was also removed from the reactor and these assemblies were replaced with other fuel assemblies.

Annual outage of Olkiluoto 2 (17 May – 4 June 2015)

The maintenance outage of Olkiluoto 2 was completed safely and all the scheduled works were completed. Approximately one-fifth of the fuel was replaced. The outage took around 17.5 days, i.e. it was around 2.5 days longer than expected. The delay was caused by problems during work on the reactor, fuel transfer and testing during startup.

In addition to the refueling, major maintenance and modifications included replacement of mixing points in the feedwater line, replacement of low voltage switchgear in trains B and C (SIMO project) and realisation of a remote shutdown station. The mixing points of both lines were replaced at OL2. The work went well: there were no problems with the pressure test like at OL1. The replacing of the low voltage switchgear was also completed as planned. The emergency control room was commissioned in compliance with the implementation decision regarding Guide YVL 5.5 and decisions made based on the periodic safety review. During the annual outage, STUK completed inspections of the remote shutdown station connection and commissioning. The Olkiluoto 1 remote shutdown station will be commissioned during the 2016 annual outage.

When inspecting the internals of the reactor pressure vessel, cracks were observed in a welded joint between a reactor core spray system nozzle and a safe-end. Fault indications regarding the welded joint of said nozzle were already made in 2011 and 2013, and the fault indication was classified as an internal failure. During the inspections made in 2015, it was observed that the failure extends to the inner surface of the nozzle, which means that the threshold value laid down in the approval standard has been exceeded. STUK approved a procedure proposed by TVO where the weld will be inspected more often for at least the next three years by means of both a qualified eddy current method and the traditional phased array ultrasonic testing method. STUK also required that TVO must continue to study the causes of the cracks in the reactor pressure vessel nozzles and continue its work on preventing new indications and preventing the old indications from spreading. At the end of 2015, TVO submitted to STUK for approval a plan on related further measures, repair plans and a review on the adequacy of the current nozzle inspection programme. The review applies to all nozzles in the reactor pressure vessels of both plant units that have been manufactured in the same manner.

When inspecting the internals of the reactor pressure vessel, cracks were also observed in a welded joint between the back plates and end plates of two feedwater dividers. Potential causes include a manufacturing fault and stress corrosion, or a combination of the two. TVO decided to replace the two feedwater dividers with feedwater dividers that have already been used before. Their flow characteristics are slightly different than those of the new dividers. Based on analyses made, TVO has determined that replacing two of the total of four feedwater dividers will not have a major impact on the distribution of flow or the thermal loads of the reactor pressure vessel. To resolve the cracking problem, TVO completed after the annual outages a study on the opportunity to modify the construction of the dividers to achieve an optimal thermal service life. Based on the survey results, TVO has decided to purchase new dividers. Their installation will take place in 2017 and 2018.

During visual fuel inspections, rods that had bent in such a manner that they were very close to the adjoining rods were observed in the outermost row at the bottom ends of two bent GNF2 test fuel assemblies. The phenomenon was somewhat more moderate in one of the studied assemblies, but TVO decided to remove all four GNF2 test assemblies from the reactor and replace them with other assemblies with a similar burnup. Nothing out of the ordinary was observed in the visual inspections of four Optima2 and Optima3 test fuel assemblies or during the length measurements of the fuel channels and fuel rods.

Ultra HD control rods delivered by General Electric were commissioned during the 2015 annual outage. The manufacturer has designed them to replace Marathon control rods. The first inspections of the new type of rods will take place after two fuel cycles. Twenty control rods were ordered from Westinghouse, and half of the ordered rods were delivered during the spring of 2015. Manufacture of the remaining ten rods started in November and will be delivered in 2016. The inspection and replacement criteria of all the control rod inspections completed during the 2015 annual outage were acceptable.

APPENDIX 4 Periodic inspection programme of nuclear power plants 2015

Inspections included in the periodic inspection programme focus on safety management, operational main processes and procedures, as well as the technical acceptability of systems. The compliance of safety assessments, operations, maintenance and protection activities (radiation protection, fire protection and security) with the requirements of nuclear safety regulations are verified by the inspections.

Periodic inspection programme 2015, Loviisa

Personnel resources and competence, 6–7 October 2015

The inspection covered the training team organisation at the Loviisa nuclear power plant, as well as the maintenance and development of the expertise of people working in safety functions. Based on the results, there is still room for improvement in the monitoring of the refresher training of people working in safety functions. This is why STUK required that Fortum assess and implement the necessary measures to ensure that all people working in safety functions participate in refresher training.

Functionality of management system and quality assurance, 19–20 November 2015

The 2015 inspection focused on the licensee's non-conformance management system. Special attention was paid to how STUK's requirements are processed in the requirement and non-conformance management system. Other inspected issues included the quality assurance organisation, as well as requirements on supplier supervision in Guides YVL A.3 and A.5 and their impact. These issues were studied by reviewing safety culture issues pertaining to topical major modification projects, the processing of non-conformances and the current status of delivery supervision plans.

Fortum is still improving the manner in which the impact of corrective measures is processed. STUK did not pose any requirements on the licensee based on the inspection.

Assessment and improvement of safety, 25 November 2015

The inspection on the assessment and improvement of safety involved design operations at the Loviisa nuclear power plant. The inspection covered electricity and process design procedures, available resources and processing of non-conformances at different design stages. An additional inspected issue was the commissioning of the Design Authority function. The function aims at ensuring that all effects are taken into account when modifying the plant or its systems to prevent a situation where a modification causes problems with another system or component.

No non-conformances that would give rise to a requirement were observed in the case of electricity and process design. The requirements of the new YVL Guides are currently being implemented into the design guidelines. Commissioning of the Design Authority function is at a testing stage: the procedures are being tested and developed. This stage will end at the end of March 2016, and the Loviisa nuclear power plant will make a decision about the future of the function at this point. STUK did not pose any requirements based on the inspection.

PRA and safety management, 2 December 2015

STUK assessed the use of the probabilistic risk assessment (PRA) in a safety management inspection that covered the current status of PRA models and applications, prepared expansions and development of PRA results. The inspection covered the licensee's PRA organisation, resources and guidelines. Processing of non-conformances within the PRA organisation was also assessed. Covered special issues included modelling of fires in specific rooms and hauling of the HP safety injection system during the 2016 annual outage in terms of the annual outage risk assessment.

The PRA model has been extensively updated over the course of the past year, and the model for Loviisa 2 has been developed. Applications for the needs of plant modification projects and the 2015 annual outage, among others, have been prepared. STUK did not pose any requirements on the licensee based on the inspection. The PRA is used as planned and in a versatile manner to support the management of safety, and no major deficiencies were observed in the inspected issues.

Plant maintenance, 13–14 October 2015

The inspection covered implementation of Guide YVL A.8 (Ageing management of a nuclear facility). During the inspection, compliance with the requirements of the new Guide YVL A.8 at the Loviisa plant units was verified by means of interviews and document reviews. The reference materials included a licensee assessment on compliance with the requirements of the Guide YVL A.8, *Ageing management of a nuclear facility*, prepared by Fortum. In the assessment, Fortum comments compliance one requirement at a time, including references to plant documentation and proposing measures to be taken to ensure future compliance with the requirements.

Based on the inspection results, one can state that the nuclear power plant's procedures meet the requirements of YVL A.8, at least in principle. No major non-conformances were observed. The issue will be studied in more detail once Fortum has submitted the ageing management programme as laid down in the Guide by the end of 2016.

Based on the inspection, STUK posed two requirements on measures launched based on the previous inspection. Fortum has developed the identification and monitoring process of ageing products (spare parts, supplies) and the monitoring of batches, and these features have been taken into use in the new Lomax system but not in a comprehensive manner yet.

Electrical engineering, 3–4 November 2015

The inspected areas included monitoring and management of the ageing of electrical engineering components, management of diesel generator and battery bank loads during modifications, management of non-conformances in connection with electrical modifications, use and maintenance of an emergency power supply connection, and installation inspections of electrical equipment and cables.

STUK performed the inspection by verifying the licensee's documentation, by assessing functionality of electrical design and by assessing guidelines. Procedures and their functionality were verified in the inspection with example cases. Furthermore, events and reporting were verified.

Based on the inspection, STUK posed a requirement on the licensee regarding delivery of emergency diesel generator condition monitoring measurement results to STUK.

I&C engineering, 3–4 November 2015

The inspected areas included management of I&C requirements and configuration, management of the validity of equipment qualifications, an I&C renewal programme, identification of programmable technology, up-to-dateness of inservice testing instructions, and management of measuring accuracy.

Due to the correction and supplementation needs observed during the inspection, STUK posed a requirement on the licensee to update the measuring accuracy review from the past decade.

Information security, 26 May 2015

The inspection involved technical and administrative information security – information security training and subcontractors' information security practices in particular – as well as procedures to manage maintenance, installation and non-conformances and their documentation.

Based on the inspection, STUK provided observations and posed seven requirements. The requirements involved information security training, layout provisions and management of information security. Requirements from the previous inspections had been properly implemented and well executed.

Mechanical engineering, 28–29 October 2015

The inspection covered the licensee's activities pertaining to the verification of the integrity and performance of selected mechanical engineering components. This year, one of the areas inspected was the procedures used to verify operability and long-term operational safety of piping and pumps important to safety. These issues were studied from the viewpoint of responsibilities, resources, competence and monitoring procedures, taking into account operating experience and the utilisation of operating experience. A special issue covered in the inspection was recent faults observed in the internals of the reactor coolant pumps and whether there is a link between these faults and the previous problems with vibration.

Based on the inspection, STUK posed three requirements on the licensee. The requirements request reports on inspections of the piping for the external containment spray system (XU), the opportunity to develop the load monitoring system in terms of thermal fatigue and primary circuit vibration.

Annual outage, 5 August – 24 September 2015

The purpose of STUK's annual outage inspections is to verify that the licensee plans and implements annual outages in a safe manner in terms of radiation and nuclear safety and that the licensee uses sufficient competence and resources. The Loviisa nuclear power plant annual outage 2015 inspection focused on work on the reactor coolant pumps. An oversight issue regarding organisations that was used in all the inspections in 2015 was taken into account: processing of non-conformances. Furthermore, an inspection of outage risks and onsite inspection visits of the facilities and worksites were performed.

STUK realised the inspection by monitoring the performance of work, verifying related documentation and interviewing employees. With this inspection, STUK verified that there are instructions for the operations, the instructions are being followed and the instructions are up to date.

No significant non-conformances in the operation of the NPP were detected. Based on the observation, STUK provided eleven observations to be assessed by the Loviisa nuclear power plant as potential development areas and issues to be continuously improved. The NPP receives observations regarding its operations also from other sources (such as internal audits and event investigations). This way, the NPP is able to see the whole picture to assess whether the inspection observations include any new or recurring issues that require improvements or additional measures.

Radiation protection, 21–22 October 2015

The radiation protection inspection was mainly targeted at dosimetry. The inspected areas included functionality of the dosimetry service, quality assurance and processing of non-conformances. The inspection also included a review of the results of a blind test. Based on the inspection results, one can state that radiation doses are determined in a manner that complies with the set goals. Results of blind tests of dosimeters have been good, in both Finnish and international tests.

It was noted, however, that Fortum used finger dosimeters whose applicability for use at a nuclear power plant has not been verified. Because of this, STUK required that Fortum submit suitability analyses for all devices that are to be used when determining the eye or finger dose rate in the controlled area of the Loviisa nuclear power plant.

It was noted during the inspection that the transfer of dose data to the dose register functions properly and the practices comply with the procedures laid down in STUK's current ST Guides. The procedures used in the transfer of dose data had been erroneously described in Fortum's internal guidelines, however. This is why STUK required that Fortum take into account the renewed ST Guides and the proposed changes when updating the radiation protection guidelines.

Fluctuation was observed in the relative difference between the surface dose and the deep dose in some cases. To be completely sure that the difference was not caused by a contaminated measuring instrument, STUK required that practices for quality assurance of dosimetry must be created to be able to study the underlying causes of the most major differences before sending the dose data to the dose register.

Emergency preparedness, 3–4 November 2015

The emergency preparedness inspection comprehensively covers the nuclear power plant's emergency preparedness arrangements. Issues that are regularly inspected include emergency preparedness guidelines, emergency preparedness facilities, emergency preparedness equipment, the emergency preparedness organisation and training for the emergency preparedness organisation. Special inspection area in the 2015 inspection was the nuclear power plant's evacuation arrangements. A brief survey about evacuation issues was arranged in connection with the annual outage.

Based on the inspection, STUK required that the emergency response plan be updated to take into account the commissioning of the new environmental monitoring system and the decommissioning of the old system.

In addition, more minor observations were made and two good practices were recorded during the inspection.

Final disposal facilities, 24–25 September 2015

The inspection involved maintenance procedures of the final disposal facility (the concrete and rock structures of the VLJ repository) and monitoring of the bedrock onsite. Implemented repairs and modifications and results of the power company's measurements, which also included measurement and analysis results for the hydrogeochemistry of the bedrock in the VLJ repository, as well as hydrological and rock mechanics monitoring measurements were studied during the inspection. With these monitoring measurements, the licensee assesses the impact of the construction of the VLJ repository and its operation on the hydrological, rock mechanics and hydrogeochemical properties of the bedrock at Hästholmen. Condition of the structural engineering structures in the disposal facility was studied during an inspection visit.

Following the inspection, STUK posed four requirements on the delivery of the currently ongoing guideline updates; these pertained to a visual inspection of the VLJ repository structures and packages, monitoring of the bedrock (setting result assessment criteria/limit values), interpretation of the VLJ repository's hydrogeochemistry and description of its normal state.

Operating experience feedback, 28 May 2015

The inspected areas included the nuclear power plant's operating experience feedback processes and their organisation as well as related guidelines and procedures. Procedures and their functionality, processing of events, reporting and sufficiency of resources were verified in the inspection with example cases. In the field of management of non-conformances, results of internal and external assessments were verified.

Operating experience feedback and related instructions at the Loviisa nuclear power plant have been developed due to the requirements of the new YVL Guides, for example. Communication between different technical offices and the processing of events have been improved by naming contact persons. Procedures connected to the assessment of the impact of corrective measures and results of corrective measures will be further monitored in connection with annual reports.

Operational waste, 21–22 May 2015

The inspection covered the processing and final disposal of radioactive operational waste at the Loviisa nuclear power plant. Low- and intermediate-level operational waste is generated during maintenance and repairs as well as during the treatment of circulating water. Issues studied during the inspection included the processing of non-conformances, HR planning and occupational radiation doses. The condition of facilities in which waste is processed and stored, radiation levels in these facilities, their classification and their markings were inspected during the site visit.

No major non-conformances or development needs were detected in the inspection. STUK posed a requirement in the inspection that the power company must prepare a plan on emptying of an onsite waste storage site and processing of waste packages that are in poor condition. In 1978–1998, low activity operational waste was packaged into barrels. Some of the waste was very humid and has caused the barrels to corrode from the inside out. According to the current procedure, Fortum packages operational waste into barrels whose inside is coated and whose walls are thicker than that of the previous barrels, and the humidity level of operational waste has been minimised.

Management and safety culture, 2 February 2015 and 17 April 2015

The inspection covered the licensee's management of nuclear operations and safety culture. STUK focused especially on monitoring and assessing how the licensee manages its management system development projects as a whole and how the different goals and actions of different projects are interwoven from the viewpoint of overall safety.

The inspection covered specific development projects selected based on a safety culture survey by VTT Technical Research Centre of Finland and a report by a special report workgroup. Current status of the management system development project (JOJO) was also studied. Based on the inspection results, the licensee's manager is more powerfully present at the nuclear power plant than before and the manager's role in the development of operations at the Loviisa NPP has been promoted. The inspection results indicated that the licensee is strongly committed in the development of nuclear safety. During the inspection, STUK verified that development projects that are important for the plant have been included in the plant's action plans and monitoring, and they are proceeding as planned. STUK noted, however, that the management review records of the NPP do not comply with all of the NPP's guidelines on records: it is not possible to verify systematically from the records what conclusions have been made and measures carried out on the basis of the made observations.

Operational activities, 7 April 2015 and 15–16 April 2015

The inspected areas included the procedure used to monitor the status of the plant, launching of a 12-hour shift system trial, follow-up of corrective actions decided on the basis of operational events and the processing of non-conformances.

During the inspection, STUK verified the nuclear power plant's documentation, monitored the performance of work and interviewed employees. In terms of the inspected areas, it was noted that there are instructions for the procedures, the instructions are up to date and the instructions are being followed. STUK observed some potential development areas in the division of labour among the shifts and required that the Loviisa NPP assess the significance of these observations.

Structures and buildings, 8–9 April 2015

In the inspection of structures and buildings at the Loviisa nuclear power plant, the maintenance procedures of structures, buildings as well as seawater channels and tunnels were assessed. In addition, the results of inspections carried out by the power company and completed modifications were studied.

The most important species in terms of the biofouling of the service water system are dark false mussel, freshwater hydroid and bay barnacle, all being species that already occur in the area. According to studies by the nuclear power plant, annual reproduction of the dark false mussel and the number of mussels in the sea area adjacent to the Loviisa nuclear power plant vary a great deal. At present, no new invasive species have been observed in the Gulf of Finland that pose a clear danger to the operation of the Loviisa NPP. The service water systems are operational as a whole, and they are inspected in compliance with the monitoring programme. Most cracks found in buildings and concrete structures are caused by wear and tear, such as superficial damage and cracks in the surface coating. Loviisa NPP renewed its damage monitoring and reporting method in 2013. New damage is now detected more efficiency than before. Roof renovation projects and projects to improve the already existing flood protection and residual heat removal with the air-cooled cooling towers are currently ongoing at the plant. STUK required that Loviisa NPP submit to STUK repair plans for the roof of the cooling water tunnel.

Chemistry, 28–29 April 2015

In its inspection, STUK assessed the power company's procedures applied to the maintenance of the chemical conditions in systems important to safety, as well as the monitoring of the radionuclide content of the reactor coolant system. Operations of the chemical laboratory are of a high quality and its personnel are committed to their work. Management of the laboratory encourage the employees to make observations and further develop the operations.

STUK required that Fortum submit to STUK a report on how resins released in the water purification process at the condensate scrubbing plant can be prevented from getting into the steam generators. Resins have been released from said system into the secondary circuit water repeatedly over the past few years. Due to these problems, new faults in the steam generator heat transfer tubes are more likely and already existing faults can spread more quickly. The tubes are one of the interfaces in the spreading of radioactivity, which means that the integrity of the tubes has high safety significance. Fortum is currently planning measures to make it substantially harder for unwanted substances to enter the steam generators.

Furthermore, STUK provided six observations regarding measurements during process transients, more efficiently reviewing operating experience reports at the laboratory, preventing contamination at sampling points, monitoring surface contamination at sampling points and functionality of fume chambers used during sampling.

Fire protection, 5–6 March 2015

The fire protection inspection covered effectiveness of the plant units' fire protection arrangements and the operations of the power company, as well as plans on modifying the fire protection arrangements.

It was verified with the inspection that the nuclear power plant's fire alarm and fire prevention systems have been inspected in compliance with the maintenance programme and the work order practices. Performance of the fire protection arrangements has been assessed with regular internal audits and also by the Eastern Uusimaa Fire and Rescue Services, the Finnish Safety and Chemicals Agency (Tukes) and the Nordic Nuclear Insurers insurance pool. In these inspections, STUK studied observed improvement proposals. STUK required that the licensee submit to STUK for information a repair plan prepared based on a condition survey of the fire water piping and a report on how penetrations in the service water system fibreglass tube meet the compartmentalisation requirements.

Observations regarding the following were also made: management of requirements, defective fire compartment penetration markings and potential risks involving a new fire water system and the service water system piping.

Nuclear security, 31 March 2015

The nuclear security inspection covered the use of key cabinets and the management of keys, the processing of non-conformances, training for the security organisation and successor planning.

Based on the inspection, STUK required marking of a limited area in the immediate vicinity of the gate building. STUK's observations involved on-the-job learning descriptions by responsible persons, logs and planning of a successor for the person responsible for security arrangements. The measures resulting from remarks made in the course of earlier inspections were considered to be appropriately implemented.

Periodic inspection programme 2015, Olkiluoto

Human resources and competence, 15–16 September 2015

The personnel resources and competence inspection covered HR resource management in compliance with the organisation and operations model implemented by the TVO Group in April 2015 and the HR organisation. Several employees in the new roles in compliance with the service and competence centre operations model (such as a service manager, a competence centre manager and a business partner) were interviewed during the inspection.

The new operating model of the TVO Group is now in use. The first service agreements are valid until the end of the year and people have been given new roles. In connection with the organisational change, HR functions were divided into a HR competence centre and a service centre. Based on the inspection and the interviews, STUK found that the service- and role-based operating model of the TVO Group has been taken into use, but some work to establish the practices is still needed. STUK will actively monitor the change. STUK did not pose any requirements based on the inspection.

Functionality of management system and quality assurance, 28–29 October 2015

The management system functionality and quality assurance inspection covered TVO's document management, recording of non-conformances and processing of non-conformances. Another inspected area was a service verifying compliance of licensing documentation in compliance with TVO's new operating model. Seven field interviews regarding the non-conformance reporting and recording procedures were performed during the inspection.

STUK verified up-to-dateness of instructions included in a variety of TVO manuals from the guideline database. Based on the inspection, the procedures applied to keeping the instructions up to date seem to be functional. Based on the interviews on the management of non-conformances, STUK noted that TVO has good prerequisites for highlighting non-conformances. However, more communication about the importance of systematic recording of observations and non-conformances in different parts of the organisation is still needed. TVO does not have any documented guidelines on how observations should be processed and communicated in joint meetings of the responsible organisation. Biannual management reviews mainly focus on quantities and the efficiency of the processing of single non-conformances.

Observations made by STUK when reviewing documentation on covering letters, cover pages, delivery of documents as logical entities and missing approval markings were studied during the inspection with the help of examples. On the basis of the inspection, STUK posed a requirement according to which TVO must assess and implement measures to eliminate the possibility to maintain a document simultaneously in two databases. TVO has a currently ongoing licensing documentation development project that aims at creating clear and standardised procedures for the preparation of licensing documentation in the entire TVO Group. According to the plans, training regarding documentation requirements will be arranged in late 2016.

Safety assessment and improvement of safety, 25 November 2015

The inspection on the assessment and improvement of safety covered design activities by TVO. The inspection covered electricity and process design procedures, available resources and processing of non-conformances at different design stages. An additional inspected area was current status of the modification work process. No non-conformances that would give rise to a requirement were observed in the case of electricity and process design. The modification work process is basically the same as before, but the changed organisation has introduced some changes in the practical operations. The new organisational structure is still at the transition stage. It is a fairly major change in the organisation's manner of organising and managing work. Furthermore, the new YVL Guides and the need to update procedures and plant guidelines to comply with the new YVL Guides must be taken into account during the change. STUK will actively monitor the progress of the change. STUK did not pose any requirements based on the inspection.

Use of PRA, 6 October 2015

STUK assessed the use of the probabilistic risk assessment (PRA) in a safety management inspection that covered the current status of a PRA update, the development of PRA results, the organisation, resources and guidelines. Processing of non-conformances within the PRA organisation was also assessed. It was noted during the inspection that TVO will comprehensively assess the need to update the PRA applications by the end of 2016. Over the course of the past year, PRA assessments have mainly been completed in connection with plant modification projects and to support the planning of the 2015 annual outages. TVO has performed quarterly risk follow-ups of operational events. No requirements were posed by STUK following the inspection. The PRA is used as planned and in a versatile manner to support the management of safety, and no major deficiencies were observed in the inspected issues.

Structures and buildings, 21–22 October 2015

In the inspection of the structures and buildings at Olkiluoto NPP, STUK focused on the maintenance procedures and management of ageing of the structures, buildings, seawater channels and tunnels, spent fuel storage and handling pools, condensate pools, fuel racks and piping supports. The inspection covered the power company organisation, the power company's inspection instructions, the power company's inservice inspections, repairs and modifications, building ageing management projects, as well as other inspections within the area of responsibility. STUK verified the execution and results of the power company's internal inspections and related reporting. As observations, STUK noted that some structural engineering guidelines have not been reviewed on time. STUK did not pose any requirements based on the inspection.

Chemistry, 11–12 November 2015

In the chemistry inspection, STUK assessed the power company's procedures applied to the maintenance and supervision of the chemical conditions in systems important to safety, as well as the monitoring of the radionuclide content of the reactor coolant system. The 2015 inspection covered the following: status of requirements and observations from the previous years, organisational units in chemistry and radiochemistry and their operations, chemical conditions and migration of radioactivity, quality assurance of the laboratory's technical operations, processing of non-conformances, and an inspection visit.

STUK did not pose any requirements based on the inspection. STUK issued four observations regarding validation measurements, taking into account job rotation risks, approval of quality assurance results, and marking of malfunctioning or damaged components. In addition, STUK identified one good practice: job rotation broadens the employees' competence and thus reduces dependence on specific employees. It also improves wellbeing and coping at work.

Fire protection, 16–17 September 2015

In the inspection of fire protection at Olkiluoto nuclear power plant, the efficiency of the NPP's fire protection arrangements and the power company's operations was assessed, and plans on modifying the fire protection arrangements and fire protection instructions were reviewed. Furthermore, management of non-conformances was studied, as well as fire inspection observations recorded over the course of the year and their processing status was reviewed. An inspection visit was performed to verify fire protection modifications and procurements. An observation regarding the organisation made during the inspection was that a management-level employee acting as the substitute of another employee may carry the responsibility linked to several duties at the same time. No goods causing extra fire loads along access routes were observed during the inspection visit. STUK did not pose any requirements based on the inspection.

Nuclear security, 8–10 April 2015

The first nuclear security inspection in 2015 covered security arrangement processes as part of the management system, as well as technical and functional implementation of security arrangements. The management system section focused on physical protection and information security, as well as issues pertaining to the interface between security arrangements and nuclear safeguards. The practical implementation section focused on physical security arrangements. Inspected areas included management of non-conformances and risks, self-assessments and practical implementation of security arrangements. The implementation of measures determined based on the requirements and observations of previous inspections is proceeding acceptably.

Following the inspection, STUK posed two requirements. The first requirement was about continuous development of the management of non-conformances: STUK required that the coverage, prioritisation and reporting of observations pertaining to potentially illegal activities or security arrangements be improved. As the second requirement, STUK required that nuclear safeguards risk management procedures must be standardised with the comprehensive company-level risk management process.

Nuclear security, 26–27 October 2015

The second nuclear security inspection in 2015 covered practical implementation of physical security arrangements. Inspected areas included training and drills linked to the maintenance of security arrangements, security arrangement events and non-conformances. The 2015 training and drill plan was realised as planned. TVO is currently developing the procedure it uses when processing the results of training and drills, security arrangement assessments based on these, monitoring of further measures and their reporting. Surveillance statistics for 2015 were reviewed during the inspection. Non-conformances were studied from the viewpoint of the processing and recording of observations made by the security organisation. STUK noted that in line with the requirements on non-conformance management in the previous nuclear security inspections, processing of observations and non-conformances should be continued to achieve an overall picture of the situation. STUK did not pose any new requirements based on the inspection.

Operational waste, 5–6 October 2015

STUK regulates and inspects the processing and final disposal of radioactive operational waste at the Olkiluoto nuclear power plant. Low- and intermediate-level waste is generated during maintenance and repairs as well as during the treatment of circulating water. An inspection of operational waste focused on remarks made during the last inspection, development since the last inspection and any important issues that have occurred. The inspection focused on waste management processes, HR planning and the occupational radiation dose. The condition of facilities in which waste is processed and stored, the condition of final disposal facilities, radiation levels in these facilities, as well as their classification and their markings were studied during the inspection visit.

No major non-conformances or development needs were detected in the inspection. TVO is planning general training on measures to reduce the amount of waste. Markings at operational waste collection points have been made clearer and fire protection in the collection and storage of waste has been improved at the Olkiluoto NPP. The occupational radiation dose is incurred when employees process waste during annual outages, transport waste, package waste and solidify liquid radioactive waste. The radiation doses have remained low when compared to the plant's total radiation doses. They have remained clearly below the individual dose limits set for employees doing radiation work.

Annual outage, 3 May – 4 June 2015

The annual outages at Olkiluoto 1 and Olkiluoto 2 took place from 3 May to 4 June 2015. During the annual outage, STUK implemented an inspection on the operations of the nuclear power plant to maintain safety and manage operations during annual outages. During this inspection, STUK monitored the work done onsite, conducted inspection visits and interviewed employees. A special inspection area in this year's inspection was replacement of a feedwater line mixing point. The mixing point is located at the junction of piping from the feedwater system and piping from the reactor coolant system of the shut down reactor where flows mix. The mixing point was replaced because cracks were detected during the 2014 annual outages. Other inspected areas included electricity and I&C work, outage risks, radiation protection, structural engineering and fire protection, the plant's operating chemistry and implementation of Olkiluoto 2 emergency control room. Nothing to remark was observed in most of the inspected areas. Based on the inspection, STUK posed one requirement regarding radiation protection procedures at the actuator level in the containment.

Mechanical engineering, 15 –16 June 2015

The areas inspected in the mechanical engineering inspection included procedures used to verify operability and long-term operational safety of piping important to safety. These issues were studied from the viewpoint of responsibilities, resources, competence and monitoring procedures, taking into account operating experience and the utilisation of operating experience. The inspection focused on vibration problems that occurred in connection with a modification of an auxiliary feedwater system recirculation line at Olkiluoto 1. Structural issues important for the modification, expert estimates on the underlying reasons of the problems, studies conducted to resolve the problems and trial runs were inspected.

It was noted that TVO's operations and reporting during the studying of the difficult vibration problem have been active and systematic. However, normal operation of the system was not analysed as carefully as would have been necessary when planning the system modification when taking into account the fact that the system was known to be problematic based on previous operating experience. Following the inspection, STUK posed four requirements. For example, STUK requires that TVO study procedures and available resources for hydrodynamic dimensioning calculations and analyses for piping system modification projects. Furthermore, STUK requires that TVO studies adequacy and functionality of measuring programmes used to verify long-term availability of piping and fatigue monitoring systems.

Emergency preparedness, 9–10 June 2015

The emergency preparedness inspection comprehensively covers the nuclear power plant's emergency preparedness arrangements. Issues that are regularly inspected include emergency preparedness guidelines, emergency preparedness facilities, emergency preparedness equipment, the emergency preparedness organisation and training for the emergency preparedness organisation. A special inspection area in the 2015 inspection was the nuclear power plant's evacuation arrangements.

Following the inspection, STUK posed three requirements. Emergency response plan updates have not been properly submitted to STUK. STUK requires that TVO submit the missing plans to STUK and specify the future emergency response plan delivery procedures. In Finland and Sweden, nuclear power plant introductory training need not be separately completed at each NPP. TVO must specify the plant-specific written emergency response training materials that supplement introductory training and that has been provided by other NPPs. STUK also required that assembly points used during evacuation must be clearly and consistently marked, and communication procedure for the assembly points must be checked and corrected in the emergency response plan.

Management and safety culture, 3–4 February 2015

The management and safety culture inspection focused on TVO's changed operating model and its potential effects on nuclear safety and the safety culture. TVO's plans and measures to ensure safety during the change were studied during the inspection. No interviews were conducted during the inspection.

TVO will implement the new operating model during the spring of 2015. The new operating model standardises procedures and strives to use resources in a flexible manner: general tasks are centralised to service centres and tasks requiring special expertise are managed by competence centres. Responsibilities on the overall management of safety are determined more clearly than before. Many employees of TVO have participated in the planning of the change, and TVO has invested in openness when implementing the change.

An independent assessment must be completed for such a major organisational change. It will be done by a party outside of TVO. STUK also required that TVO assess the change after implementation and submits an assessment report to STUK for information by the end of 2015.

Operating experience feedback, 8–9 April 2015

In the operating experience feedback inspection, STUK verified operating processes and the organisation, as well as related guidelines and procedures. Utilisation of internal and external operating experience feedback and results of new safety analyses were studied during the inspection. Processing and reporting of events and utilisation of operating experience feedback from other plants were verified with the help of example cases.

No requirements were posed by STUK following the inspection, but some observations regarding the processing of non-conformances were made in the inspection. Communication of information within the organisation has been slow in the case of some events. STUK also pointed out that the annual reporting of operating experience feedback in 2014 did not comply with all of the YVL Guide requirements. The annual reporting in 2015 will be assessed based on the new Guide YVL A.10.

Conduct of operations, 12–13 March 2015

The operational activity inspection aimed at verifying the operating organisation's non-conformance management procedures. STUK focused on three inspection areas: inspection rounds in compliance with an inspection list by the operating shift at the plant, TVO's internal operational activity audits and management of non-conformances in the operational organisation.

STUK participated in the inspection rounds included in the inspection list with the morning shift. Inspection rounds in the inspection list aim at a systematic verification of compliance of the plant's rooms and equipment with the requirements. It was verified during the inspection that the inspection rounds were completed in compliance with the plant's own guidelines. TVO has a current development project whose goal is to include monitoring of a variety of operating observations as part of the inspection rounds in the inspection list. Furthermore, more detailed instructions about the issues field operators must inspect with special care (such as fire loads and earthquake risks) will be given. In terms of the processing of the operating organisation's non-conformances, it was noted that all measures had been completed on time and the operations complied with the instructions.

All the inspected areas were deemed fine. STUK made some observations but did not pose any requirements based on the observations.

Plant maintenance, 30–31 March 2015

During the inspection, compliance with the requirements of the new Guide YVL A.8, *Ageing management of a nuclear facility*, at the currently operating Olkiluoto plant units was verified by means of interviews and document reviews. A previous statement of TVO on compliance with said Guide was also used as reference material. Another area that was inspected was the means used to prevent the procurement of counterfeit products.

Compliance with some of the requirements on ageing management could not be verified. Clear proof of, for instance, the ability to verify the operability of a train included in a system realised using the redundancy principle independently from other systems could not be verified and no proof about instructions to verify that key information and competence needed to take care of duties will be retained in case employees are replaced could be obtained. TVO's ageing management will be revisited in later inspections once the Guide YVL A.8 has entered into force. To prevent counterfeits, TVO will provide training to its personnel and update its instructions regarding the following issues: procurements, supplier assessment and inspection manual. Counterfeits can be identified by, for instance, a visual inspection where the product is compared with a similar product or by verifying quality certificates of the entire subcontracting chain. Based on the inspection, TVO has access to the means needed to prevent counterfeit products from entering the plant (or reduce the risk caused by the use of counterfeits).

Electrical engineering, 10–11 March 2015

The electrical engineering inspection covered the effects of the Fukushima and Forsmark events on the electricity and diesel systems of the Olkiluoto nuclear power plant, monitoring of the ageing of electrical equipment, power distribution system in case of a severe reactor accident, processing of non-conformances, programmable electrical equipment and electrical equipment commissioning inspections. Based on the inspection results, STUK required from TVO for information reports on detected unqualified electrical equipment and management of the ageing of electrical equipment.

I&C engineering, 10–11 March 2015

The I&C engineering inspection covered unfinished issues pertaining to measuring accuracy from the previous inspections, the I&C design and implementation process in connection with the transfer to the new YVL Guides, results on studies about devices that do not comply with their markings, management of non-conformances in I&C technology and change design, and the management of ageing. Based on the inspection, development of the I&C design and implementation process in connection with the application of the new YVL Guides is an issue to be monitored.

Information security, 28–29 April 2015

The information security inspection covered practical implementation of information security. Inspected areas included classification of data systems, nuclear information security, impact of the organisational change on information security, plant modifications to be implemented during the annual outage, assessment of systems' information security and information security control selection procedures. The status of requirements and observations from previous inspections was also reviewed. Their implementation has proceeded in an acceptable manner.

Based on the inspection, STUK issued two requirements. The first requirement was about hardware configuration management and the second was about the assessment and reporting of information security events.

Radiation protection, 18–19 March 2015

The radiation protection inspection was mainly targeted at dosimetry. The inspected areas included functionality of the dosimetry service, quality assurance and processing of non-conformances. Based on the inspection results, one can state that radiation doses are determined in a manner that complies with the set goals.

Radiation doses of employees exposed to radiation are determined with passive and real-time electronic dosimeters. Official radiation doses are determined with passive dosimeters. This is not possible at all times, however, in which case radiation doses are assessed with the help of information obtained from real-time dosimeters. The underlying reason in most cases is that employees fail to return their passive dosimeters right after their shift. The number of assessed doses has remained high over the past few years. On the basis of the inspection, TVO was requested to prepare a report on which measures could be used to reduce the number of assessed radiation doses.

APPENDIX 5 Construction inspection programme of Olkiluoto 3 in 2015

The objective of the Olkiluoto 3 construction inspection programme is to verify that the operations required by the construction of the unit ensure a high quality implementation according to the approved plans and are compliant with official regulations, without compromising the operating units within the site. The inspection programme assesses and oversees the licensee's operations in constructing the unit, implementation of procedures in various technical disciplines, the licensee's competence and use of expertise, the processing of safety issues, as well as quality assurance and control. The inspection programme of Olkiluoto 3 was launched in 2005 when construction of the unit started. The number of annual inspections has varied between nine and fifteen.

In 2015, 13 inspections included in the construction inspection programme were implemented, one of which was an unannounced inspection. Special focus areas of the construction inspection programme included commissioning procedures and activities at the construction site. Below is a brief description of the inspection findings for which STUK required improvements from TVO. On the whole, the inspections have led to the conclusion that the procedures and resources of TVO's organisation are adequate.

The **nuclear security** inspection focused on security arrangements during commissioning and practical implementation of nuclear security. As a result of the inspection, STUK required delivery of a schedule for commissioning activities that are important in terms of nuclear security to STUK. Furthermore, TVO was requested to provide reports on installation supervision information security inspection procedures, reporting practices and experiences, as well as methods used to protect rooms important to safety.

The **I&C** inspection covered installation, testing and change management practices. No requirements were posed by STUK following the inspection; TVO's activities were appropriate and the inspectors received a positive image during the inspection. Activities regarding change management procedures during commissioning were still at their early stages and will be revisited in later inspections.

Subject of inspection	Inspection date
Nuclear security	25–26 February 2015
PACS I&C system supervision procedures	3 March 2015
Quality assurance: implementation of YVL Guides	14–15 April 2015
Installation supervision	21 April 2015
Management and processing of safety issues	18–19 August 2015
Nuclear security in management system and technical implementation of security arrangements	16–17 September 2015
Testing of safety functions and their supporting functions during commissioning	22 September 2015
Commissioning of ventilation and air conditioning systems	23 September 2015
Unannounced installation supervision inspection	29 August – 5 September 2015
Electrical engineering	15–16 October 2015
Quality assurance	4–5 November 2015
Radiation safety	17–18 November 2015
Utilisation of PRA	26 November 2015

The **quality assurance** inspection covered the organisational reform, development of guidelines and studies required for implementation of the new regulatory guidelines. One requirement was issued during the inspection on delivery of a plan concerning the plant guidelines to STUK.

The **installation supervision** inspection covered TVO's readiness for installation supervision as the construction site becomes busier. It was noted that TVO has established installation supervision practices and practices for the orientation of new contractors. Based on the inspection results, TVO's resources are sufficient. No requirements were posed in the inspection.

The **unannounced installation supervision** inspection covered installation supervision resources once the installation activities have become busier. Site visits were conducted to verify the adequacy of installation supervision resources in different engineering disciplines both during and after normal working hours. The possibility of TVO's installation supervision organisation to react to changing resource needs in the future and the size of installation supervision resources when compared to the installation workload were also assessed. The resources were deemed sufficient, but TVO was requested to make preparations for the changing resource needs.

The **electrical engineering** inspection covered change management, preparation for the commissioning phase, orientation of the subcontractor doing electrical installation work in the containment and installation supervision resources. No defects in the licensee's operations were observed during the inspection. One requirement was issued during the inspection on presenting a work report on the mapping of software-based components to STUK.

The **management and safety issue processing** inspection covered the effects of TVO's organisational reform on resource management and the clarity of roles, in particular. In addition, processing of safety issues and communication within the TVO organisation were verified by means of examples. No defects in the licensee's operations were observed during the inspection.

Two inspections on **commissioning** were performed. One of the inspections involved coverage of safety function testing, assessment of testing coverage, managing of larger entities in testing programs and during actual testing. As part of the inspection, STUK interviewed experts in commissioning testing, reviewing testing programs and nuclear safety. The second commissioning inspection focused on ventilation and air conditioning system trial runs. The inspection covered maintenance during commissioning, change management, special air conditioning requirements in specific rooms and orientation of new employees participating in commissioning. TVO's procedures were deemed sufficient and STUK did not pose any requirements in these inspections.

The year's second **nuclear security** inspection focused on security arrangements during commissioning. Practical implementation of security arrangements was verified during an site walk-down. The status of observations and requirements from previous inspections was also reviewed. All requirements from previous inspections were closed. The site walk-down covered the reactor building, outdoor areas and the logistics chain in the nuclear power plant area. Based on the inspection, STUK posed one requirement regarding the plant database.

The **quality assurance** inspection in the autumn covered effects of TVO's organisational reform, preparation for the submission of the operating licence application and the management of open issues. No requirements were posed in the inspection.

The **radiation safety** inspection covered resources of the radiation protection organisation, preparation for commissioning of the controlled area and radiation protection acquisitions. In addition, TVO's measures in assessing the correctness of the N16 source term were studied. The inspection included an site walk-down, during which future locations of water and air effluent monitors and sampling points were verified, for example. Based on the inspection, TVO was requested to assess sufficiency of its radiation protection personnel resources.

The inspection on utilisation of the **probabilistic risk assessment** (PRA) covered the current status and verified TVO's inspection and supervision actions in relation to the plant supplier's PRA work. No requirements were posed by STUK following the inspection.

APPENDIX 6 Inspections pertaining to the processing of Fennovoima's construction licence application

During the processing of the application documentation linked to the construction licence application of the Hanhikivi 1 plant project, STUK assesses both technical compliance of the plant and ability of the organisations of the licensee, the plant supplier and the main service providers to construct and ultimately operate a nuclear power plant.

In addition to studying the management systems of these actors, STUK conducts inspections to verify that the operations of the organisations comply with the requirements in practice. STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. Inspections are planned biannually. In 2015, STUK carried out a total of six inspections. The inspection results will be used when preparing STUK's safety assessment for the construction licence.

Management and processing of safety issues

An inspection on Fennovoima's management and the processing of safety issues, arranged on 14–15 September 2015, covered the role and actions of Fennovoima's management in the identification, monitoring and processing of safety issues. As a result of the inspection, STUK stated that Fennovoima has allocated resources to guide the plant supplier's design in such a manner that it will meet the Finnish safety requirements, but Fennovoima's internal procedures to prove compliance of design, such as design inspection procedures, are still partially unfinished. STUK required that Fennovoima develop the procedures so that nuclear safety and radiation safety issues will be taken into account to a sufficient extent in design inspections and approvals. Furthermore, STUK required that independent workgroups be utilised to support and assess Fennovoima's work when preparing the permit applications laid down in the Nuclear Energy Act.

Management system and key processes

The inspection on the management system and key processes took place from 29 September to 2 October 2015. The inspection covered readiness of Fennovoima's management system and Fennovoima's work on further improving nuclear safety in a manner compliant with the plant project's needs. Fennovoima's risk management and readiness to manage the project's supply chain in compliance with the Finnish requirements were also assessed. Both Fennovoima's own procedures and requirements posed by Fennovoima for the organisations involved in the project were assessed in the inspection.

Since this was STUK's first inspection of Fennovoima's management system, several development areas were observed, such as aware-

Subject of inspection	Inspection date
Management and processing of safety issues	14–15 September 2015
Management system and key processes	29 September – 2 October 2015
Fennovoima's safety culture	16–18 November 2015
Nuclear security	30 November – 1 December 2015
Resources and competence management	8–9 December 2015
Principal designer inspection	16–18 December 2015

ness of the management system, supplier supervision procedures, processing of non-conformances, and assessment and development of the management system. In addition, STUK required from Fennovoima a long-term development plan that takes into account different construction phases and future operation of the nuclear power plant.

Fennovoima's safety culture

The inspection, arranged on 16–18 November 2015, covered Fennovoima's safety culture and actions of the management to promote the safety culture. Importance of issues influencing safety in the operations of Fennovoima, the management's actions when communicating safety issues and the general atmosphere at the company, particularly in terms of the processing of safety defects and safety concerns, were studied during the inspection. Furthermore, Fennovoima's procedures in assessing and developing the safety culture were assessed. The procedures of Fennovoima's own organisation in the assessing and developing safety culture as well as Fennovoima's own actions to ensure good safety culture in the supply chain were studied.

As a result of the inspection, STUK stated that safety has not always been the primary guiding factor in the processing of documents at Fennovoima; instead, adherence to schedules has been deemed more important than comprehensive processing. STUK required from Fennovoima an action plan for the implementation of a safety culture development programme to improve management practices and make the atmosphere open and transparent. Furthermore, STUK required from Fennovoima a report on nuclear sector expertise and experience of the company management and an assessment of the company's strategic goals and future challenges when taking into account preparation for operation of the nuclear power plant and the actual operational phase.

Nuclear security

The nuclear security inspection took place from 30 November to 1 December 2015. The inspection covered Fennovoima's structural, technical, operative and organisational arrangements to detect and prevent illegal and unauthorised activities. Fennovoima's arrangements and procedures were deemed mostly appropriate in the inspection.

Resources and competence management

The inspection, arranged on 8–9 December 2015, covered Fennovoima's resources and competence management. In the inspection, Fennovoima presented its procedures to develop the nuclear and radiation safety competence of its organisation. Fennovoima's competence development principles were deemed appropriate in the inspection. STUK posed a requirement in the inspection that Fennovoima name positions important to safety within its organisation as laid down in the Government Degree on the Safety of Nuclear Power Plants (717/2013). Furthermore, STUK required that orientation plans for new employees be prepared, their realisation be monitored and implementation of planned orientation be verified.

Principal designer inspection

On 16–18 December 2015, STUK assessed procedures of the principal designer of the Hanhikivi 1 project, Atomproekt, in an inspection in St. Petersburg. STUK's inspection verified development of the principal designer's management system and whether the design operations of AP comply with the Finnish requirements. The inspection focused especially on Atomproekt's design management procedures and guidelines. Configuration management and requirement management procedures were verified during the inspection, among others. Following the inspection, STUK posed requirements on further development of said processes and the designer's management system for open issues. Furthermore, STUK required a report on design and project management resources allocated to the FH1 project. STUK also posed a requirement on preparing instructions specific to the FH1 project for the preliminary safety analysis report. Requirements regarding the preparation of system quality plans and system qualification plans were also posed. In its summary, STUK emphasised the analysis of the observations made in the preliminary safety assessment in the principal designer's organisation and traceability in plant and system design.

APPENDIX 7 Construction inspection programme for the encapsulation plant and disposal facility

When the construction licence was granted in late 2015, the oversight project launched the construction inspection programme (RTO). Inspections included in the programme assess the functionality of Posiva's management system, the sufficiency of procedures and their ability to guide design, manufacture, construction and installation operations, as well as the taking into account of safety requirements at different stages of the nuclear waste disposal facility project. The programme aims at assessing Posiva's procedures to ensure that a safe nuclear facility of a high quality will be constructed. Inspections included in the programme may also be targeted to Posiva's suppliers important to safety.

Since the programme was launched in late 2015 once the construction licence had been granted, there were only two inspections in 2015. Below are brief descriptions of the inspections, as well as the key observations made based on which STUK had required improvements and development actions from Posiva. A total of twelve requirements on correcting deficiencies or further developing its operations were submitted to Posiva in the inspection decisions.

Monitoring effects of underground construction activities

The inspection area was limited as the hydrology, hydrogeology, hydrogeochemistry and rock mechanics of research facility Onkalo and the future disposal facility, as well as monitoring of foreign materials. Purpose of the inspection on the monitoring of the effects of underground construction activities was to verify how the Posiva organisation implements the monitoring programme published in 2012. The inspection covered the monitoring organisation, instructions for different monitoring areas and assessment procedures for the effect of the underground construction activities on the safety features of the nearby bedrock. Quality assurance of monitoring results and reporting, as well as the reporting itself, were also studied.

One goal of the monitoring by Posiva is to monitor the effects of the construction of the research facility Onkalo and later on the underground disposal facility on the bedrock at Olkiluoto. Posiva aims at proving that the properties of the bedrock surrounding the disposal facility that are favourable towards long-term safety of final disposal will be retained. Furthermore, the monitoring will provide data to be used when describing properties of the final disposal location and specifying of a variety of models and the verification of forecasts based on these models. The monitoring data can also be used in the Olkiluoto EIA procedure and environmental radiation monitoring.

As a result of the inspection, STUK required that Posiva develop procedures to minimise the delays observed in the annual reporting of hydrogeochemistry and foreign material monitoring. The inspection also proved that Posiva still needs to develop the analysis methods of the rock mechanics monitoring programme and its results. Furthermore, Posiva needs to verify in the future that the procedures used when reviewing and approving quarterly memorandums comply with the requirements of Posiva's document management process.

Management

The management inspection covered actions by Posiva's management regarding preparation for

Subject of inspection	Inspection date
Monitoring effects of underground construction activities	26–27 November 2015
Management	9–11 December 2015

the construction phase, verification of sufficient personnel resources and competence, as well as assessment and further development of the Posiva safety culture. The inspection also covered the current status of Posiva's organisational reform and related changes in responsibilities and policies.

As part of the inspection, STUK interviewed eight people within the Posiva organisation. Some of them are employees of TVO. The interviews were conducted in order to obtain information about what the employees of Posiva think about the new organisational model and its impact on their duties. A summary of the interview observations was presented during the inspection, and representatives of Posiva stated that the observations made were consistent with their own experiences and personnel survey results.

Goals of the organisational reform implemented by Posiva in November 2015 and the updated strategy on which the change is based were studied during the inspection. Posiva has submitted to STUK management and organisation manuals updated to comply with the new organisational model. The manual describes, at a general level, the utilisation of TVO's resources and new programmes, among others.

Posiva previously submitted to STUK a plant project resource plan as part of the construction licence application documentation. Current status of personnel resources and competence could not be verified in the inspection because the organisational reform and planning are still unfinished. Posiva's personnel resource plan is being updated due to the project plans of the new organisation, preparation for production and the Group's resource planning. This is why STUK required that Posiva submit to STUK resource plans for the different programmes and plant projects, and a report on the resources and competence available in 2016. Furthermore, STUK required that Posiva submit long-term resource plans for these programmes and plant projects.

When processing the construction licence application, STUK has verified, as part of the inspection programme, that Posiva's procedures for the construction phase are sufficient. A draft of Posiva's updated project plan was reviewed during the inspection. The project plan describes the goals of Posiva's operations from the present to the closing of the first disposal tunnel. Based on the inspection, Posiva's management and implementation during the construction phase will be described in the project plan, the project steering plan and the programme plans. The inspection focused especially on how Posiva has planned to assign responsibilities, duties and operating methods from the previous plant project to the new organisational model to the required extent. Posiva's preliminary plan, presented during the inspection, is to expand the project process descriptions and procedures used in the plant project to cover Posiva's project management or all of Posiva's operations via the management system.

As one of the requirements based on the inspection, STUK required that Posiva submit to STUK a plan on key management system guidelines that need to be updated due to the organisational reform. The plan must cover the necessary issues needed to include the requirements, processes and procedures described in the plant project instructions into the documents guiding the project and the implementation of programmes and projects. Furthermore, Posiva must submit to STUK a project plan, a project steering plan, plans for the programmes and plant projects, as well related quality and risk management plans in compliance with the requirements of the YVL Guide.

A safety culture programme prepared by Posiva in early 2015 states that Posiva needs to, taking into account the special characteristics of the project stage, obtain the support of TVO, which has operated nuclear power plants for a long time. In the inspection, Posiva stated that it will close its own safety culture programme and participate in the Group-level safety culture programme in the future. In this respect, STUK required that Posiva assess how well the Group-level safety culture programme and the safety culture workgroup correspond with Posiva's management manual, Posiva's safety culture programme and the policy of Posiva's safety culture workgroup.

With this requirement, STUK required that Posiva document the Group-level management system development and assessment procedures, responsibilities and obligations due to the changed operating model.

According to the policy of Posiva's safety culture workgroup, the workgroup prepares an annual report that includes the workgroup's assessment of the status of Posiva's safety culture. STUK required that this assessment be submitted to STUK for information.

APPENDIX 8 Licences and approvals in accordance with the Nuclear Energy Act in 2015

Teollisuuden Voima Oy

- 1/G42214/2014, 16 January 2015, OL3 – Import of a boron concentration measurement system from Germany and import of neutron source elements and a thermal shield from France. Last date of validity 31 January 2018.
- 1/C42214/2015, 11 March 2015, import of technical design documents of a neutron flux measuring system for reactor units OL1 and OL2 from Japan. Last date of validity 31 January 2018.
- 3/C42214/2015, 13 October 2015, import of nuclear fuel with Euratom obligation code "P" from Sweden (OL2 e 36). Last date of validity 31 January 2016.
- 4/C42214/2015, 13 October 2015, import of nuclear fuel with Euratom obligation code "S" from Germany (OL1 e 38). Last date of validity 31 January 2016.
- 6/C42214/2015, 9 November 2015, OL1/OL2 – import of reactor coolant pumps from Germany. Last date of validity 31 January 2018.

Fortum Power and Heat Oy

- 14/Y42214/2014, 19 January 2015, possession and transfer of nuclear information concerning the Fennovoima NPP to Fennovoima Oy, Platom Oy and VTT Technical Research Centre of Finland. Last date of validity 31 December 2023.
- 4/A42214/2015, 26 May 2015, import of neutron flux detectors for Loviisa 1 and 2 from France. Last date of validity 31 December 2015.
- 5/A42214/2015, 26 May 2015, Loviisa 1 and 2 – import of intermediate shafts of the control rod drive mechanism from the Czech Republic. Last date of validity 31 December 2015.
- 10/A42214/2015, 9 November 2015, import of new fuel from Russia and transport to the Loviisa nuclear power plant. Last date of validity 31 December 2027 in terms of the fuel for Loviisa 1 and 31 December 2030 for Loviisa 2.

Others

- 1/F42214/2015, 19 January 2015, VTT Technical Research Centre of Finland; possession and transfer of nuclear information concerning the Fennovoima plant to Fennovoima Oy, Fortum Power and Heat Oy and Platom Oy. Last date of validity 31 December 2023.
- 16/Y42214/2014, 19 January 2015, Platom Oy; possession and transfer of nuclear information concerning the Fennovoima NPP to Fennovoima Oy, Fortum Power and Heat Oy and VTT Technical Research Centre of Finland. Last date of validity 31 December 2023.
- 8/Y42214/2015, 15 September 2015, Geological Survey of Finland; possession, processing, use and storage of nuclear materials. A maximum of 15 g of special fissionable materials. Last date of validity 31 January 2025.